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Short Range Air Defense (SHORAD) Engagement Performance Criteria

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This report presents and discusses the development, administration, and calibration of standards for qualification of Short Range Air Defense (SHORAD) operators. The objective is to develop range tables that the U.S. Army Air Defense Artillery School (USAADASCH) can use to determine the proficiency level of air defense soldiers for training and qualification. A review of the air defense literature and recent air defense empirical data was conducted. As a result of this review, air defense scenarios, scenario difficulty factors and weights, summary and task performance measures, performance scoring algorithms, performance feedback displays, air defense criteria cutoffs, and performance criteria test administration procedures and test conditions were developed. A preliminary examination of the scenarios, the difficulty indexes, and the criteria was conducted using field test data obtained during this effort using the Realistic Air Defense Engagement System (RADES), a SHORAD testbed and trainer. The preliminary performance standards will be subjected to a series of validation tests to ensure their representativeness and to further calibrate them according to scenario difficulty level.

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SHORT RANGE AIR DEFENSE (SHORAD) ENGAGEMENT PERFORMANCE CRITERIA

EXECUTIVE SUMMARY

Requirement:

To determine operator engagement task and summary performance parameters, scenarios, scenario difficulty scaling factors, performance measures, performance scoring, and performance criteria, and test administrative procedures for applying qualification standards to Military Occupational Specialty (MOS) 16P, 16S, and 16R soldiers. The required research products combine to form the Short Range Air Defense (SHORAD) systems performance criteria and applications procedures.

Procedure:

The draft SHORAD performance criteria were determined by means of the analysis of field test and experimental data collected in the Realistic Air Defense Engagement System (RADES) testbed and trainer. A scenario difficulty weighting procedure was employed to assess agreement between empirically defined scenario difficulty indexes and scenario difficulty ratings ascribed by subject matter experts.

Findings:

Results obtained from field test experiments and the RADES multi-experiment database were used to determine engagement performance standards attainable by SHORAD personnel. Performance variations were consistent with expert ratings in determining scenario difficulty levels. Multidimensional performance criteria and scenario difficulty scales were determined and will be subjected to empirical validation.

A fully integrated and automated, scenario-specific feedback and multiscenario scoring system was also developed and tested. Over 200 training and test scenarios were developed and indexed by performance difficulty level. Performance criteria cutoffs and administrative procedures have been outlined, implemented, and tested, in anticipation of future validity testing.

Utilization of Findings:

The proponent for this research was the Directorate of Training and Doctrine (DOTD), United States Army Defense

Artillery School (USAADASCH). These results and draft standards were briefed to the Director, DOTD, on 26 September 1988. This research will form the basis for draft standards of performance for SHORAD crews in associated gunnery tables.

SHORT RANGE AIR DEFENSE (SHORAD) ENGAGEMENT PERFORMANCE CRITERIA

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SHORT RANGE AIR DEFENSE (SHORAD) ENGAGEMENT PERFORMANCE CRITERIA

OVERVIEW

Operational Problem

At the request of the Directorate of Training and Doctrine (DOTD) of the US Army Air Defense Artillery School (USAADASCH), and with the suport of the US Army Missile Command - Target Management Office (MICOM-TMO), the Army Research Institute is developing a Range Target System (RTS). The RTS provides sustainment training, qualification, and certification of Short Range Air Defense (SHORAD) crews, teams, and operators in engagement simulation and live fire exercises. The RTS will also support future Forward Area Air Defense System (FAADS) components. These include the Line-of-Sight-Foward-Heavy (LOS-F-H), Line-of-Sight-Rear (LOS-R), and Non-Line-of-Sight (NLOS) weapons system and the Forward Area Air Defense Command, Control, Communication, and Intelligence (FAAD C^3I) system.

A critical component of the RTS will be the range tables, the basis of which will be derived under this program of research. The RTS configuration and this research effort are interdependent projects. The RTS promises to be the means of institutionalizing range table procedures, scenarios, performance measures, scoring, and performance criteria in a way that will improve ADA collective crew readiness Armywide. The range tables and associated RTS are expected to be fielded as an integrated product to ensure an objective crew sustainment and qualification program of training and evaluation.

The product of this research will be valid, reliable, practical, and economical engagement performance range tables for use in SHORAD crew, team, and operator sustainment training and qualification testing, which are compatible with the emerging Range Target System.

Research Objective

The research objective is to determine the range table components. First, test and training scenarios are needed. Second, performance difficulty level indexes are needed to partition the scenarios for training and test purposes. Third, engagement performance task and summary performance measures are required to diagnose the errors. Fourth, engagement performance criteria (i.e., performance standards) are needed to quality soldiers and to establish minimum acceptable levels of performance. Fifth, range table administrative procedures and scenario feedback, across-scenario scoring algorithms, displays, and hardcopy report formats are needed to ensure proper utilization and information payoffs from the application of the range tables.

Approach

The approach was to repeat a pre-defined sequence of subtasks until the research objective had been successfully attained. These subtasks were:

- Scenario Scripting and Generation
- Scenario Administration Conditions Specification
- Summary and Task Performance Measures Specification
- Scoring Algorithm Development
- Scenario Feedback Display Definition
- Hardcopy Multi-Scenario Scoring Report Development
- Expert Rating of Scenario Difficulty Factors
- Collection of Individual Soldier Differences Data
- Field Test Data Collection
- Multi-Experiment Database Management and Analysis
- Target Parameters and Distribution Specification
- Field Test Data Analysis

Soldiers served on an as available basis. Subtasks were performed in various sequences to capture meaningful soldier performance data. Fortunately, the Realistic Air Defense Engagement System (RADES) already had the task and summary performance measurement capabilities needed, so field test performance data could be captured and stored for later use in range table development and verification. The RADES testbed was therefore employed to meet essential data requirements.

RADES

RADES is an instrumented testbed and SHORAD engagement simulation exercise (ESX) system. SHORAD soldiers employing their actual weapon systems engage scaled fixed wing (FW) and pop-up rotary wing (RW) aircraft in an outdoor desert environment under controlled field test conditions. As many as five weapons and their associated crews, teams, or operators can be tested or trained at a time. Direct weapon connections automatically collect interrogation friend or foe, acquisition, track, lock-on, uncage, superelevate, fire, and launch signals from the weapon. Detection, identification, and command to engage or cease engagement voice commands are collected using human data collectors at computerized data acquisition stations. The human data collectors enter event data via the data collection station keyboard.

RADES synthetically flies missile rounds to target intercept and evaluates the outcome as a kill or miss, predicated on the status, location, and range of the aircraft at time of intercept. Time delays in software ensure that effects are not provided to the weapon team or crew until the intercept would have occurred under fullscale conditions. RADES automatically records the reason for any assessed engagement miss (e.g., aircraft out of range, failure to acquire, no lock-on at fire, failure to superelevate, etc.). The RADES host computer provides aircraft status, location, and range data to the data collection stations during realtime engagements. The host also collects and consolidates the data into an aggregate test file at the end of every engagement trial. It is this aggregate data file that is returned from the field site for database management and analysis.

RADES research has demonstrated the following situational effects on air defense performance (Barber, 1987):

- Target Characteristics
  - Aspect, elevation, azimuth (offset), size, type, and range

- Weather and Terrain Conditions
  - Visibility, weapon position, target background (contrast), atmospheric conditions (wind, temperature)

- Individual Differences
  - Sensory, perceptual, psychomotor, cognitive, and personality

- Level of Training and Scenario Difficulty
  - Experience, workload, and practice level

- Command, Control, Communications, and Intelligence (C^3I)
  - Alerting, cuing, reliability of information

- Doctrine and Tactics

BACKGROUND

In many ways this research is directed at correcting current deficiencies in existing engagement performance criteria, criterion-referenced standards, qualification scenarios, and test administration procedures. Current engagement qualification and training criteria and standards of engagement performance are deficient in the following ways:

- Counterair Effectiveness (ordnance delivery prevention is not considered by existing scoring procedures).

- Friendly Air (the effects on performance of complicating friendly air elements and corresponding fratricide rates are not included in current qualification and certification testing processes and standards for all SHORAD systems).

- Task Difficulty (the significant effects of scenario- and environment-imposed task performance difficulty are not considered in the development and ordering of scenarios for test and training purposes).

- Achievable Performance Levels (criteria have not been developed, nor are they administered, with consideration of achievable soldier performance levels).

- Collective Crew Engagement Performance testing and qualification (current standards are directed solely at gunner part-task qualification and do not include crew chief, squad leader, or team chief tasks).

- Test Administration Controls and Procedures, qualification test scenarios, and test conditions (current qualification and certification testing procedures are subject to a large amount of user interpretation and vary considerably in test administration practices and environmental conditions from one application and unit location to another).

To overcome these weaknesses in current engagement performance qualification and certification testing, ARI, at the request of the Directorate of Training and Doctrine (DOTD), formulated a comprehensive approach to formal range table development.

As a result, the present research has given rigorous attention to those factors not normally addressed, or only modestly treated, in the determination of previous qualification standards of performance. These contributions include the:

- Crew, team, and operator distribution parameters for each Summary Performance Measure
- Impact of using a weapon control status of "tight" versus "free"
- Effect of introducing multiple targets simultaneously or sequentially
- Effect on Summary Performance Measure scores of introducing friendly aircraft
- Effects of including the squad leader
- Impact on crew performance of including an ordnance delivery prevention criterion
- Effects of various types of alerting and cuing
- Consideration of soldier capability limitations which affect performance

FINDINGS AND PERFORMANCE CRITERIA COMPONENTS

This section describes the requirements, procedures, and findings for all the subtask actions conducted in this study. Specifically addressed are the:

- Multi-Experiment Database Analysis
- Definition of Range Table Scenario Test Conditions
- Range Table Scenario Scripting and Scenario Generation
- Definition of Summary Performance Measures (SPM) and Task Performance Measures (TPM)
- Scoring Algorithm Development
- Scenario Feedback Display Definition
- Determination of Scenario Difficulty Factors
- Scenario Field Testing
- Determination of SPM and TPM Cut-off Scores

The report includes a discussion of findings directly addressing the future actions toward fielding of the SHORAD sustainment training and qualification testing range tables.

Multi-Experiment Database Management and Analysis Results

Requirement: To establish baseline performance parameters for Short Range Air Defense (SHORAD) system crews, teams, and operators, and to generate databases on human performance from which to draw generalizations about the ADA population.

Procedures: Air defense engagement part-task and summary performance efficiency and effectiveness were measured under a wide variety of environmental and scenario test conditions using the RADES testbed over a period of two years. Individual difference measures on participating soldiers were also obtained coincident with those experiments contributing to the RADES multi-experiment database.

Test Conditions: Analyses were based on prior test results obtained from RADES experiments. The experimental conditions existing during these tests were clear weather, daylight conditions. Data reflected the performance of SHORAD crews and teams reacting to 1/7th scale, flying fixed wing (FW) aircraft and 1/5th scale, pop-up rotary wing (RW) aircraft. Results from the following field tests were consolidated to produce a meta-analysis.

- Chaparral Weapon Control Status and Identification Friend or Foe (IFF) Experiment
- Redeye Weapon Control Status and Training Experiment
- Stinger Terrain and Target Characteristics Experiment
- Stinger Early Warning and Cuing Experiment
- Tripod Mounted versus Man-Portable Stinger Experiment
- Enhanced RADES Observer Experiment
- Stinger Training Experiment

Table 1 presents the dependent variables used in the meta-analysis. Average scores for these variables were derived based on weighted means with extreme outliers (i.e., + or - 3 standard deviations) removed. Average scores were derived by taking the mean of all observations for a single crew or team for a given scenario type. Therefore, while multiple observations were obtained from each crew, the sample sizes reflect the total number of crews participating, not the total number of observations.

These past investigations focused upon different experimental manipulations and controls. Hence, the results presented in this section should be viewed as the overall, expected performance of the SHORAD population aggregated across weapon systems and experimental conditions. These conditions included:

- Weapon systems (Stinger, Chaparral, and Redeye)
- Experience and training level (trainees to NCOs)
- Target aspects and offsets (face, tail, and side views)

- Target approach azimuth and flight profile
- Target background (sky versus terrain)
- Early warning and cuing (varied in method, delay time, update rate, content, and accuracy)
- Alert status and weapons control status ("red free", or "red tight")
- Rotary wing range (2.5 km to 7 km, fullscale)
- Soldier differences (vision, demographics, and personality)

Table 1
Dependent Variables

CODE	TITLE or DESCRIPTION	DUTY	INTERPRETATION
RDET	Range of Detection	SL or SG	The slant range from the weapon to the target when the event took place. Range is relevant for fixed wing targets only since rotary wing targets simply popped-up from a static position. Ranges are given in full scale kilometers.
RID	Range of Identification	SL	
RLOCK	Range of Track or Lock-on	SG	
RFIRE	Range of Weapon Fire	SG	
TDET	Time of Detection	SL or SG	Based on seconds after target availability where availability begins when visual line-of-sight is achieved.
TID	Time of Identification	SL	Time interval between Detect and Identification
TLOCK	Time of Lock-on	SG	Time interval between Detection and Lock-on.
TFIRE	Time of Weapon Fire	SG	Time interval between Lock-on and Fire.
THAND	Time of Handoff	Both	Time interval between Identification and Fire.
TTOT	Total Engagement Time	Both	Time interval between Detection and Fire.
IDCOR	Correctness of Identification	SL	Number of correct identifications divided by number of targets identified.
PKILL	Probability of Target being engaged and destroyed	Both	Number of aircraft destroyed divided by number presented.

KEY: SL = Team or Squad Leader
SG = Senior Gunner

Findings: Data from the first set of single target (FW and RW) trials from several RADES tests were consolidated. From these consolidated data, engagement parameters were estimated. The performance data provided herein represent overall results drawn from two years (1985 and 1986) of RADES experiments.

Table 2 lists summary performance results for the SHORAD population for FW and RW targets in terms of overall engagement outcomes. Table 3 provides FW aircraft ranges in full scale kilometers for critical engagement outcomes as a function of aircraft intent (hostile or friendly). Table 4 provides these data relative to aircraft intent for each model type. Table 5 presents the approximate RW aircraft event times in seconds for critical engagement outcomes as a function of aircraft intent. Table 6 presents these data as a function of aircraft intent for each model type. Blank spaces in these tables indicate that the data were missing or the sample sizes were too small to be meaningful.

All rotary wing event times were based on the time when line-of-sight (LOS) was first established. LOS was defined as the point in time at which the helicopter rotor blades first broke the terrain masking. The entire helicopter became visible approximately 2 seconds after that.

Engagement Parameter Estimates: The fixed wing engagement event sequence and the rotary wing engagement event sequence have been depicted in Figures 1 and 2, respectively. These figures show approximate population parameter values associated with critical engagement part-task events by target type (FW or RW), and illustrate how these events unfold. The greatest potential for improvement in engagement performance can be afforded by increasing the range at which aircraft are detected, identified, and acquired. Smooth tracking, lock, and fire task actions are rather tightly grouped in terms of their time and range of occurrence. Thus, if the range of detection, identification, and acquisition are extended, the subsequent ranges of track, lock, and fire will result in greater ranges of engagement.

Figures 3 and 4 depict the overall expected distributions of the SHORAD population with respect to FW and RW engagement events, respectively (assuming a normal distribution). Some sample distributions contributing to the population estimates were skewed. Therefore, it must be noted that the population standard deviations may be lower than those reported here, while the means are believed to be representative of the population. The recommended criteria were approximated from various source documents which specify weapons system and soldier performance requirements (US Army DCD, 1987; Headquarters, Dept. of the Army, 1988). These criteria are indicated in Figures 1 and 2 with an "*" and in Figures 3 and 4 with a "C". The criteria indicated in Figures 1-4 are arbitrary, and do not represent classified data.

Table 2
SHORAD Summary Performance Data

	FW		RW	
SUMMARY PERFORMANCE MEASURES	%	N	%	N
Correctness of ID	75	49	85	57
Hostiles Engaged	77	37	81	57
Friends Engaged	39	37	23	57
Engaged Aircraft Destroyed	92	33	85	41
Hostile Attrition	72	31	76	41
Friendly Fratricide	35	31	19	41
Hostiles Releasing Ordnance	62	37	83	41

Table 3
FW Event Ranges (in kilometers) and Performance Outcomes by Intent

	FRIENDLY		HOSTILE		OVERALL	
	MEAN	SD	MEAN	SD	MEAN	SD
RDET	10.8	2.7	10.8	3.7	10.8	3.2
RID	5.7	2.2	6.0	2.4	5.8	2.3
RLOCK			5.3	3.5		
RFIRE			4.7	3.4		
IDCOR	72%		79%		75%	
PKILL			72%			

Table 4
FW Event Ranges (in kilometers) and Performance Outcomes by Model Type

	FRIENDLY											
	A7			A1Ø			F16			F111		
	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N
RDET	1Ø.3	2.Ø	25	11.3	2.5	27	8.1	2.2	44	13.4	4.Ø	18
RID	6.6	2.4	2Ø	7.Ø	2.1	27	4.5	1.2	44	4.9	3.Ø	18
RLOCK												
RFIRE												
IDCOR	8Ø%			89%			62%			59%		
PKILL												

	HOSTILE								
	SU24			SU25			MIG27		
	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N
RDET	11.3	4.4	18	1Ø.7	3.5	35	1Ø.5	3.1	61
RID	5.8	2.6	17	6.6	2.2	34	5.5	2.3	55
RLOCK				4.6	3.4	14	6.Ø	3.6	25
RFIRE				4.2	3.4	14	5.3	3.4	27
IDCOR	7Ø%			83%			84%		
PKILL				77%			77%		

Table 5
RW Event Times (in seconds) and Performance Outcomes by Intent

	FRIENDLY		HOSTILE		OVERALL	
	MEAN	SD	MEAN	SD	MEAN	SD
TDET	8.7	2.5	7.2	3.5	8.3	3.5
TID	8.6	4.1	5.4	3.0	7.0	3.5
TFIRE			2.8	2.6		
THAND			5.2	3.7		
TTOT			11.0	3.7		
IDCOR	80%		90%		85%	
PKILL			82%			

Table 6
RW Event Times (in seconds) and Performance Outcomes by Model Type

	FRIENDLY								
	AH1			UH1			CH3		
	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N
TDET	8.2	3.6	40	11.1	2.4	9	7.6	1.5	8
TID	8.2	4.9	40	9.0	2.9	9	9.0	4.6	8
TFIRE	2.2	0.8	15						
THAND	4.0	1.5	19						
TTOT	12.4	6.5	21						
IDCOR	77%			87%			75%		
PKILL	14%								

	HOSTILE								
	MI8			MI24			MI28		
	MEAN	SD	N	MEAN	SD	N	MEAN	SD	N
TDET	6.7	3.2	43	6.9	4.0	44	10.9	3.4	9
TID	5.4	3.1	40	5.0	3.3	41	5.7	2.0	9
TFIRE	2.3	1.6	39	3.3	3.0	41	2.4	3.3	9
THAND	4.8	2.9	44	5.3	4.1	44	9.4	6.3	9
TTOT	9.9	3.0	44	9.9	4.5	44	15.1	7.1	9
IDCOR	90%			94%			87%		
PKILL	88%			77%					

Figure 1

FW Engagement Event Sequence

Range in Fullscale Kilometers

```
-----------------------------------------------------------------
| 1     2     3     4 *  5     6     7     8     9    1Ø    11    12    13 |
-----------------------------------------------------------------
|                       Lock                       Det            |
|                       (5.3)                    (1Ø.8)           |
|                     ▽--△-▽-------------------------△----------- |
|                     Fire  ID                                     |
|                    (4.7) (5.8)                                   |
-----------------------------------------------------------------
```

* = Criterion

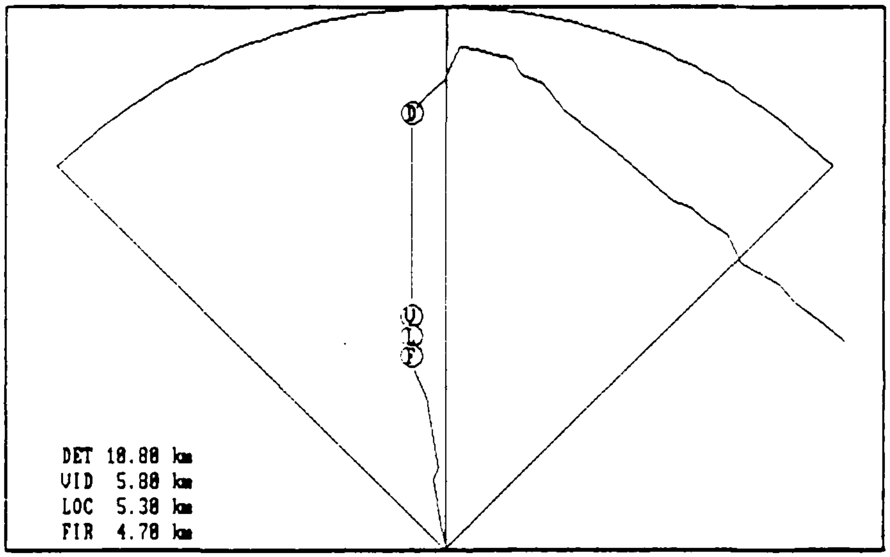


Figure 2

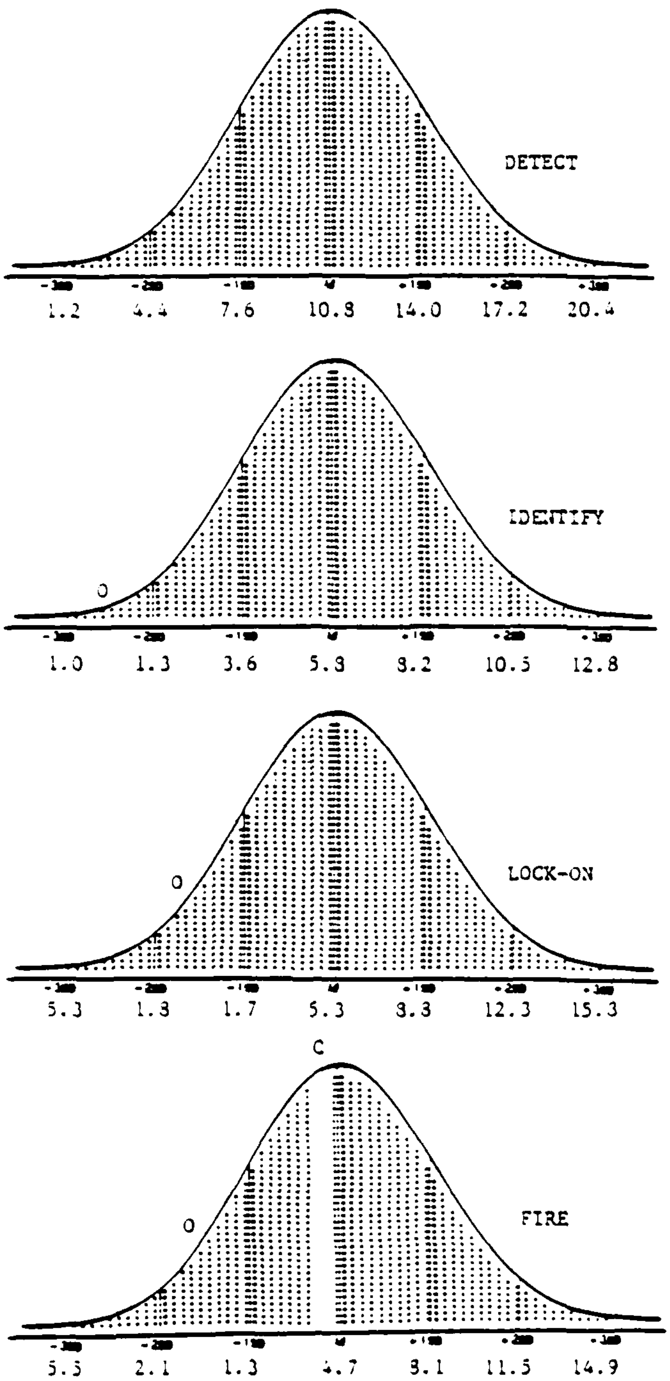
RW Engagement Event Sequence

Time in Seconds

```
-----------------------------------------------------------------
| 24*   22    2Ø    18    16    14    12    1Ø    8     6     4     2     Ø |
-----------------------------------------------------------------
|                     Lock                 Det                    |
|                    (16.2)               (8.Ø)                   |
|               ▽-------△▽------------------△---------------------▽ |
|              Fire      ID                                   LOS  |
|             (19.Ø)   (15.Ø)                                      |
-----------------------------------------------------------------
```

* = Criterion

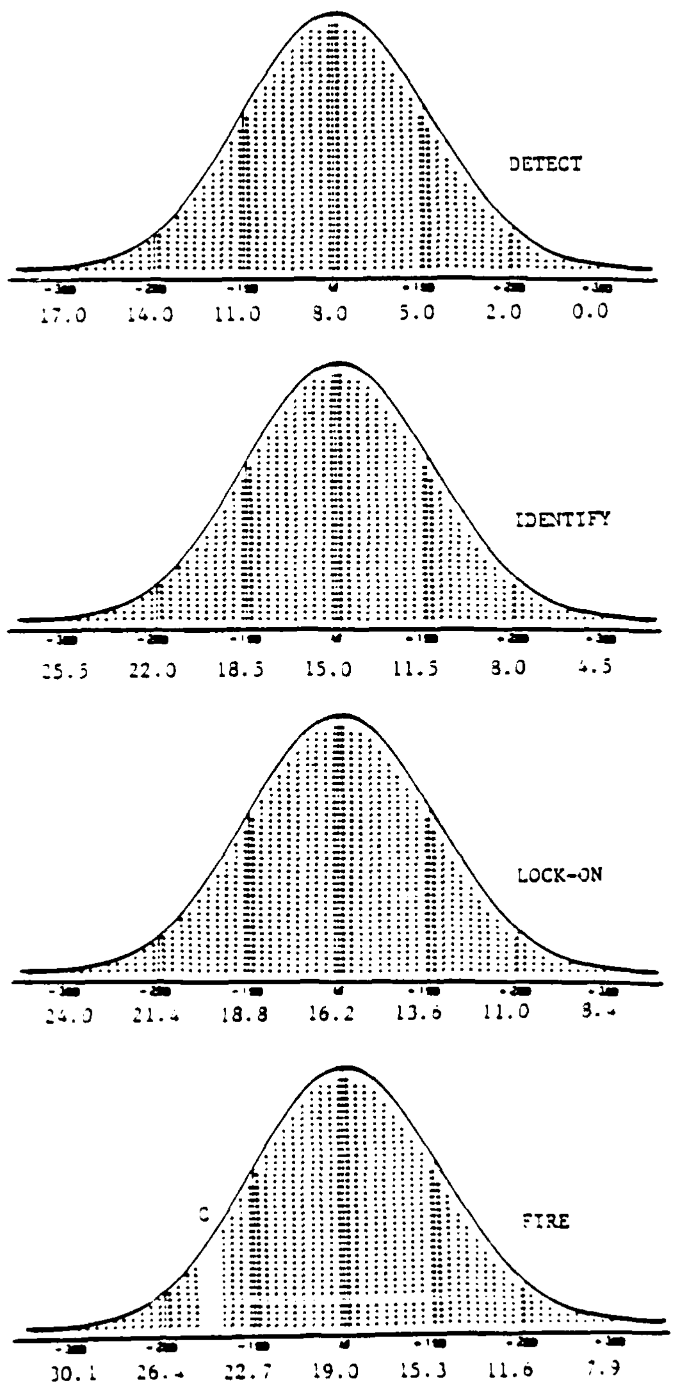
Distributions for FW Events (Kilometers)



KEY: O=target outbound
C=criterion

Figure 3

Distributions for RW Events (Seconds)



KEY: C=criterion

Figure 4

Consistency of Estimates with Full Scale Test Results: The parameter estimates presented were found to agree with data obtained from field tests conducted using full scale aircraft. Tables 7 through 10 present comparisons (when experimental conditions were similar enough to warrant a comparison) and demonstrate the consistency of RADES data with full scale field test data. Readers are also referred to the RADES Validation Report (Drewfs, Barber, Johnson, and Frederickson, 1988).

Conclusions: The purpose of the meta-analysis was to consolidate similar studies which investigated the same phenomena, in order to make generalizations about the SHORAD soldier population. The findings reported are assumed, for purposes of range table development, to be the best available approximation of the true population parameters based upon an aggregation of a series of RADES experiments (Barber, 1987).

A major conclusion of the meta-analysis was that the detection, identification, and acquisition of aircraft consume the majority of the engagement process. Improvements in detection and identification range and accuracy would result in major gains in overall SHORAD engagement efficiency and effectiveness. Some gains could also be found by selecting soldiers with superior vision, and providing the fire unit with accurate, timely, and consistent early warning and cuing information. Use of RADES or RTS for training and qualification testing and troop unit sustainment training would increase hostile attrition and fratricide avoidance at optimal ranges. This is because it enables soldiers to practice and master aircraft identification and engagement skills, against friendly and hostile targets, in a realistic range environment.

Another important conclusion was that many soldiers currently appeared to fall below the performance criteria for fixed wing engagements; only half the population met the criterion. Again, improvement could likely be acquired by reducing the time and increasing the range of detection, identification, and acquisition. While RW performance was consistently above criterion, the criterion failed to consider helicopter ordnance release prevention. Assuming an ordnance delivery time of 18 to 19 seconds for a helicopter popping-up and hovering at a range of 3 to 4 kilometers, half the population would be above and half below this adjusted criterion, indicating a situation similar to that found for fixed-wing.

It is also important to note that the meta-analysis only considered single target presentations, and did not cover the effects of multiple or sequential targets. Previous research in RADES has often shown poorer performance in conditions with multiple targets than in conditions with single targets.

Table 7
Fixed Wing Event Range Comparisons (in kilometers)--
Wright (1966) versus RADES (1987)

	RADES			WRIGHT		COMPARISON		
VAR	Mean	SD	N	Mean	N	t-value	df	2-tailed p
RDET	10.0	3.2	52	10.0	27	1.05	77	p>.2
RID	5.8	2.3	52	6.8	27	1.82	77	p>.05

NOTE: Assumes equal variances

Table 8
Fixed Wing Event Range Comparisons (in kilometers) for the A7 and A10--Tillapaugh & Smith (1983) versus RADES (1987)

	A7			A10		
VAR	t-value	df	2-tailed p	t-value	df	2-tailed p
RID	1.0	38	p>.2	0.10	56	p>.2
RFIRE	1.5	38	p>.2	2.31	49	.01<p<.05

NOTE: RADES "fire" value based on data from hostile aircraft only

Table 9
Friendly Rotary Wing Event Time Comparisons (in seconds)--
Lott (1977) versus RADES (1987)

Time Interval : Detection to Identification		
t-value	df	2-tailed p
0.10	56	p>.2

NOTE: Assumes equal variances

Table 10
Helicopter Event Time Comparisons (in seconds) for the AH1--CDEC (1978) versus RADES (1987)

	RADES			HAT (3-4 km)			HAT (2-6 km)		
VAR	Mean	SD	N	Mean	SD	N	Mean	SD	N
TDET	8.2	3.6	40	9.5	8.1	24	10.5	9.1	32
TID-DET	8.2	4.9	40	6.5	12.1	24	6.0	8.6	32
TID*	16.4	4.9	40	16.0	12.7	24	16.5	11.6	32

*Indicates time from line-of-sight to identification response

	RADES vs. HAT (3-4 km)			RADES vs. HAT (2-6 km)		
VAR	*t*-value	df	2-tailed p	*t*-value	df	2-tailed p
TDET	.89	62	p>.2	1.4	70	p>.1
TID-DET	.79	62	p>.2	0.25	70	p>.2
TID*	.18	62	p>.2	0.05	70	p>.2

*Indicates time from line-of-sight to identification response

The final observation that warrants discussion relates to assessed aircraft kills. The rate of fratricide was somewhat high, and unacceptable to the friendly air community (19% and 35% in Table 2; 14% in Table 6). The attrition rate on hostiles was below the established limits (military standards require 75% and the achieved level was 60% to 70%). This reflects a need to include the requirement to discriminate friendly and hostile air elements in training as well as in qualification and certification testing.

Definition of Scenario Test Conditions

Requirement: To define live fire exercise (LFX) and engagement simulation exercise (ESX) test conditions and aircraft model inventory requirements needed for the proper administration of SHORAD training and qualification testing scenarios. Test conditions and aircraft model specifications must insure an equal probability of successful performance across weapons, crews, teams, and operators, within each particular difficulty level grouping of scenarios.

Procedures: Scenario test conditions were profiled for both engagement simulation and live fire test purposes. Differences in live fire range safety and testing procedures mandated that the two test conditions be specified separately. Draft test conditions specifications were then provided to ARI representatives for review and comment. Comments received back from ARI were then used to adapt the draft test conditions specifications.

Findings: Table 11 provides recommended specifications for test conditions, and Table 12 lists recommended aircraft model specifications for the LFX and ESX engagement range tables. While live fire specifications may change, given developments in live fire procedures, less change is expected in ESX test conditions specifications. Figure 5 presents the basic ESX range layout utilized during field tests associated with criteria development and validation efforts.

Scenario Scripting and Generation

Requirement: To establish a library of engagement qualification and training scenarios for use in administering the SHORAD range tables. The scenario library must be inclusive of a full range of factors known to alter SHORAD part-and whole-task performance difficulty (e.g., alerting and cuing, target size, target type, target number, and target intent).

Table 11
Recommended Test Conditions

Engagement Simulation (ESX)	Live Fire (LFX)
• Sky Background	• Sky Background
• Clear Day (20+ Miles Visibility)	• Clear Day (20+ Miles Visibility)
• Stationary Weapon Position	• Stationary Weapon Position
• 90 degree Search Sector	• 90 degree Search Sector
• Unaided Detection	• Unaided Detection
• Aided Recognition (binoculars)	• Aided Recognition (binoculars)
• Cuing (+ or - 15 degrees accuracy)	• Cuing (+ or - 15 degrees accuracy)
• Early Warning Voice Message (60 seconds prior to availability)	• Early Warning Voice Message (60 seconds prior to availability)
• Air Defense warning Red, WCS Tight	• Air Defense warning Red, WCS Free
• IFF Return Unknown	• IFF Return Unknown
• One RW Practice Trial	• One RW Practice Trial
• No trial-by-trial Feedback (End of day feedback)	• No trial-by-trial Feedback (End of day feedback)
• No Visitors at Weapon Site	• No Visitors at Weapon Site
• Windspeed not to Exceed 25 MPH	• Windspeed not to Exceed 25 MPH
• Randomized Scenario Order	• Randomized Scenario Order
• Standardized Scenario Set	• Standardized Scenario Set
• Standard Target Coloration	• Standard Target Coloration
• Matched Target Sizes	• Matched Target Sizes
• RW Range: Stinger = 2 to 5 Km; Chaparral = 2 to 5 Km; Vulcan/PIVADS = .5 to 1 KM	• RW Range: Stinger = 2 to 5 Km; Chaparral = 2 to 5 Km; Vulcan/PIVADS = .5 to 1 KM
• FW Availability - 20 to 30 Km	• FW Availability - 10.5 Km
• FW Airspeed - 80 to 100 MPH (1/5 Scale)	• FW Airspeed - 80 to 100 MPH (1/5 Scale)
• 4-Hour Blocks	• 2-Hour Blocks

Table 12
Recommended Aircraft

FIXED WING		ROTARY WING	
Friendly	Hostile	Friendly	Hostile
A10 Thunderbolt	MIG27 Flogger	UH1 Iroquois	MI8 Hip
A7 Corsair	SU17 Fitter	UH60 Blackhawk	MI24 Hind
F16 Falcon	SU24 Fencer	AH64 Apache	MI28 Havoc
F111 Strike-Bomber	SU25 Frogfoot	CH3 Green Giant	MI? Hokum

Targets that are "similar" in size

- A7 and F16 and SU25
- A10 and MIG27 and SU17
- F111 and SU24
- UH60 and AH64
- CH3 and MI24 and MI28

Procedures: RADES scenario scripting software was used, along with the DBASE III Plus relational database management software package, to establish the initial set of 20 scenarios. Scenario scripts were then produced for a basic library of 200 scenarios. Given approval of the 200 scenarios by ARI, the 200 scenarios will be encoded for use in the RTS. The 20 baseline scenarios were used as the test stimulus in SHORAD range table tryout testing.

Findings: Appendix A provides the 200 developed scenarios for air defense range table qualification and training purposes. While these are draft scenarios, SAIC has taken considerable care to preserve the scenario goals of DOTD and ARI in their construction. In addition, an SAIC estimate of situational difficulty is provided in the table, which takes into consideration those factors shown by the RADES meta-analysis and recent field data collection efforts to affect performance and workload.

Summary and Task Performance Measures Definition

Requirement: To define summary performance measures (SPM) which discriminate qualified crew, team, and operator engagement performance from unqualified performance:

- Under a wide range of scenario difficulty conditions,

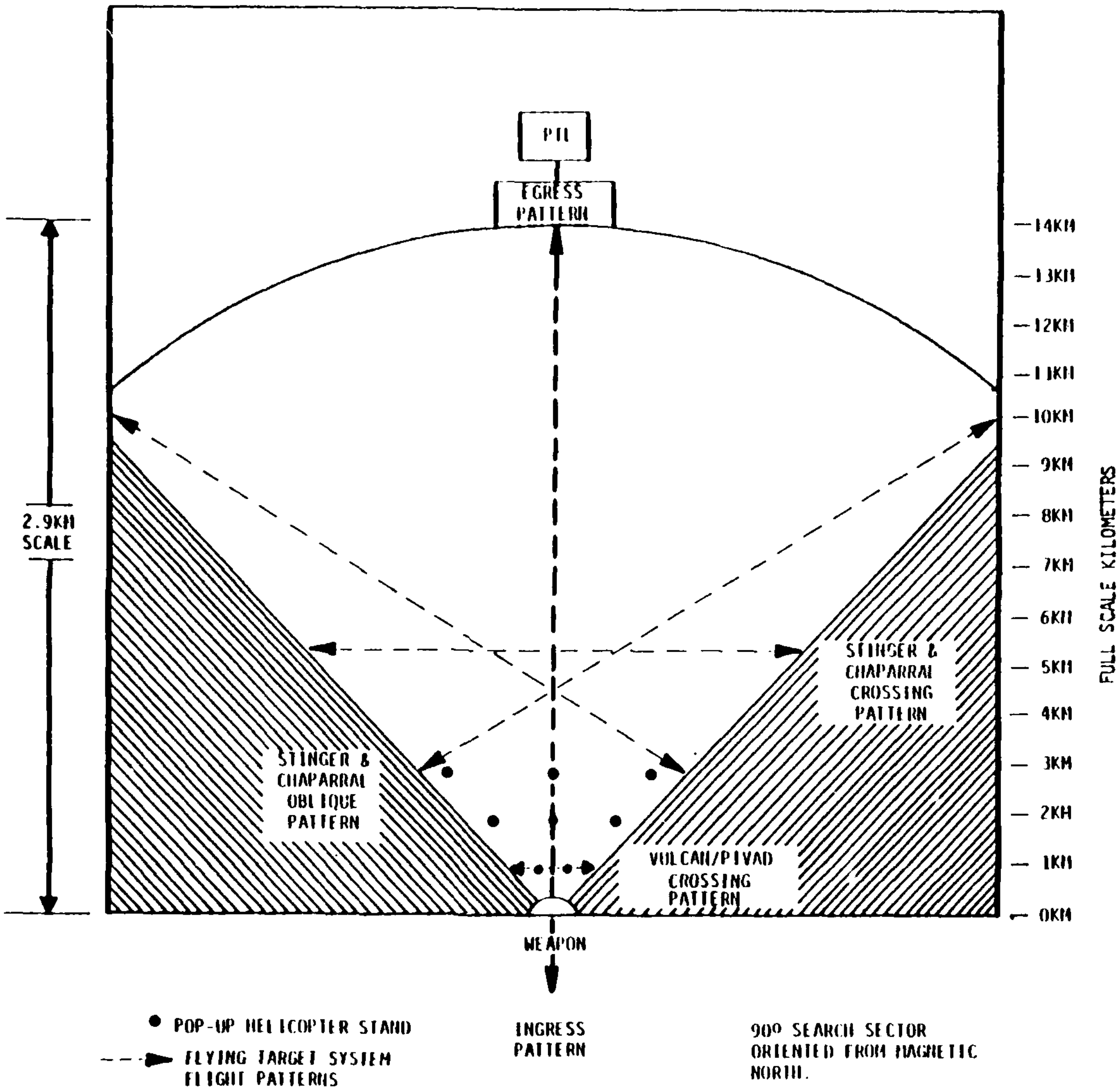


Figure 5
Range Layout

- Under a wide range of environmental conditions,
- Across the existing family of SHORAD weapon systems (i.e., Vulcan or PIVADS, Chaparral, and Stinger),
- Remaining sensitive to the individual differences of sub-groups of soldiers comprising the SHORAD soldier population.

A second requirement was to define part-task performance measures (TPM) which pointed to the sources of crew, team, or operator SPM failure, and which could be used validly, reliably, practically, and economically to assign corrective training actions:

- Across difficulty levels of scenarios,
- Across environmental conditions,
- Across the existing family of SHORAD weapon systems.

Procedures: SPM and TPM were selected if they had been shown in prior field test experiments to separate crews, teams, or operators on the basis of variation in performance. The measures sought were those sensitive to performance efficiency (speed, or TPM) or effectiveness (accuracy, or SPM), and of value in distinguishing between qualified and unqualified crews, teams, and operators. In addition, measures useful in diagnosing the sources of unqualified performance were also identified. In this regard, SPM and TPM which were selected demonstrated substantial variance. The ones that didn't were those for which performance was virtually perfect (95% or above), and they were not selected.

Table 13 lists all summary performance measures and definitions developed under the present research program. In addition, under LFX data collection operations, the SPM of number of rounds in the target area, mean hit point, and average miss distance, were integrated into the SPM set. Table 14 lists all task performance measures and definitions developed under the present research program. These candidate TPM and SPM were reduced after demonstrating which ones did not discriminate levels of achievement effectively.

Findings: What was sought in this analysis was maximum discrimination between groups on the basis of performance level. TPM which did not contribute to performance discrimination were dropped from further consideration. For example, fixed wing event response times were shown in prior RADES research applications to contribute little to the discrimination of high, medium, and low performers while fixed wing event ranges were extremely useful. Thus, only the event ranges were considered essential as FW TPM. The summary performance measures recommended for elimination were percent targets detected and percent aircraft identified. Both of these measures tended to exceed 95% in the RADES experiments conducted to date. These variables should not be confused with "percent targets correctly identified", or "time and range of detection and identification" as these are among the most important measures studied within the present research effort. Further, the interrogation (IFF) event was found to be ineffective in discriminating achievement level, and was recommended for elimination from the criterion set. Instead, IFF was recommended for use as a teaching point, as this event should occur as soon as the target has been detected. Finally, the range and time of command to engage or cease engagement were found to correlate very highly with the identification event, so only the identification ranges and times were recommended for use as criteria.

Scoring Algorithm Development

Requirement: To establish a free-standing software package compatible with the Range Target System. The package must transform raw exercise data, calculate TPM and SPM scores, compare the calculated scores with TPM and SPM criterion cut-off values, and output hardcopy reports. Hardcopy reports must be produced for each respective crew, team, and operator, scenario performance difficulty level, and aircraft type class (RW or FW), such that only "like" scenarios scores are reported within any one hardcopy report for each crew.

Table 13
Candidate Summary Performance Measures (SPM)

CODE	EVENT	DESCRIPTION	DUTY
PDET	Proportion of Aircraft Detected	Number of detections divided by presentations	SL & SG
PID	Proportion of Aircraft Identified	Number of identifications divided by presentations	SL
IDCOR	Correctness of Identifications	Number of correct IDs divided by presentations	SL
FIDCOR	Friendly Identifications	Number of correct IDs divided by presentations	SL
HIDCOR	Hostile Identifications	Number of correct IDs divided by presentations	SL
ENGAGE	Aircraft Engaged	Number of engagements divided by presentations	SL & SG
FENG	Friendlies Engaged	Number of engagements divided by presentations	SL & SG
HENG	Hostiles Engaged	Number of engagements divided by presentations	SL & SG
FRAT	Friendly Fratricide	Number of friendly kills divided by presentations	SL & SG
ATTRIT	Hostile Attrition	Number of hostile kills divided by presentations	SL & SG
EFFECT	Engaged Aircraft Destroyed	Number of kills divided by engagements	SL & SG
ORD	Hostiles Releasing Ordnance	Number of ordnance releases divided by hostile presentations	SL & SG

Table 14
Candidate Task Performance Measures (TPM)

CODE	EVENT	DESCRIPTION	DUTY
RDET	Detection	FW slant range at detection	SL & SG
RACQ	Acquisition	FW slant range at acquisition	SG
RIFF	Interrogation	FW slant range at interrogation	SG
RID	Identification	FW slant range at identify	SL
RENG	Command Engage or Cease Engage	FW slant range at command engage or cease engagement	SL
RLOCK	Lock-on	FW slant range at lock-on	SG
RFIRE	Fire	FW slant range at fire	SG
RHAND	Hand-off	FW range interval from identify to fire	SL & SG
RTOT	Total	FW range interval from detect to fire	SL & SG
TDET	Detection	RW time interval from LOS to detection	SL & SG
TACQ	Acquisition	RW time interval from detect to acquire	SG
TIFF	Interrogation	RW time interval from detect to IFF	SG
TID	Identification	RW time interval from detect to identify	SL
TENG	Command Engage or Cease Engage	RW time interval from identify to command engage or cease engagement	SL
TLOCK	Lock-on	RW time interval from acquire to lock-on	SG
TFIRE	Fire	RW time interval from lock-on to fire	SG
THAND	Hand-off	RW or FW time interval from identify to fire	SL & SG
TTOT	Total	RW or FW time interval from detect to fire	SL & SG

Procedures: The research team employed RADES field test data as the example input. These files, containing raw field data from prior experiments, were fed into a prototype score calculation procedure. This resulted in associated TPM and SPM scoring outputs. Next, a pass-fail determination routine associated with SPM scores was generated, based on realistic qualification cut-off values. Then the TPM diagnostics calculation procedure was developed, which would indicate which TPM contributed most to whether SPM criteria were met or not. Utilities were added for the purposes of calculating scores for all crews associated with a multi-station test facility, specifically the multiple-weapon RADES configuration. New test data collected using the RADES testbed were brought in from the field on floppy disk, and fed into the newly-developed software scoring system to assess the degree of consistency with prior results. This was the final test and calibration step in the procedure for algorithm development.

Findings: After prototype development and testing, the scoring transformation algorithms and software implementing those algorithms were verified as operational. Table 15 provides the final score transformation algorithms and Table 16 depicts an example of the hardcopy report output for RW time data. Not shown in the algorithm figure is the filter used to deal with measures whose values are missing due to invalid engagement sequences, or equipment malfunctions. This software filter automatically prevents the miscalculation of scores due to missing values. (While the scoring system is currently written in DBASE III Plus command language, it is anticipated that this software will be either compiled into, or translated into, the "C" programming language in order to increase execution speed. That translation will be part of the RTS integration and demonstration program).

Scenario Feedback Display Definition

Requirement: To establish scenario-specific performance standards to be displayed as feedback which can be used in the sustainment training of SHORAD crews, teams, and operators. The scenario feedback display system is meant to be integrated into a field testing and sustainment training facility such as RADES or the RTS. It is currently anticipated that the feedback displays will not be used during SHORAD qualification and certification test exercises but will be used exclusively for training purposes. Use of the feedback displays in association with testing could alter the performance of tested crews, teams, or operators and result in invalidation of the performance standards.

Procedures: A modification of the previous RADES feedback display system (see Figures 6 and 7) was used as the prototype for future SHORAD training feedback. The major alteration made to this ARI-approved and field-tested display (not shown in figures) was the addition of task performance measure cut-off values (criteria), so that not only actual but required performance can be seen by the exercising soldiers and their instructors. These criterion values could then be compared easily to achieved soldier performance.

Findings: Figures 6 and 7 provide examples of the SHORAD crew, team, and operator feedback display. It is important to distinguish the feedback display, which is scenario-specific, from the scoring system and hardcopy reports, which cover all scenarios administered to a crew, team, or operator in the course of a qualification and certification test or training exercise. While feedback displays are generated one per trial for training purposes, hardcopy scoring reports are generated for training or test purposes, after several or all of the scenarios have been administered.

Table 15
Scoring Transformation Algorithms for RW Time Data

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1. If time of interrogation friend or foe greater than or equal to time of detection, transformed time of interrogation friend or foe equals time of interrogation minus time of detection.

2. If time of identification greater than or equal to time of detection, transformed time of identification equals time of identification minus time of detection.

3. If time of acquire greater than or equal to time of detection, transformed time of acquire equals time of acquire minus time of detection.

4. If time of command to engage greater than or equal to time of identification, transformed time of command to engage equals time of command to engage minus time of identification.

5. If time of command to cease fire greater than or equal to time of identification, transformed time of command to cease fire equals time of command to cease fire minus time of identification.

6. If time of lock-on greater than or equal to time of acquire, transformed time of lock-on equals time of lock-on minus time of acquire.

7. If time to superelevate is greater than or equal to time of command to engage, transformed time to superelvate equals time to superelevate minus time of command to engage.

8. If time of fire greater than or equal to time of lock-on, transformed time of fire equals time of fire minus time of lock-on.

9. If time of fire greater than or equal to time of command to engage, transformed time of hand-off equals time of fire minus time of command to engage.

10. If time of re-attack (second fire) greater than or equal to time of fire, transformed time of re-attack equal time of re-attack minus time of fire.

11. If time of kill greater than or equal to time of fire, transformed time of kill equal time of kill minus time of fire (i.e., round flight time). Round flight time computations were based on approximations of classified data to protect their sensitivity.

Table 16. Scoring Algorithm Output

FIXED WING SCENARIO: DIFFICULTY=HIGH

TASK PERFORMANCE MEASURES DIAGNOSTICS

****

TPM	MEAN	STATUS	CRITERIA
RANGE OF DETECTION	11768	MEETS CRITERION	8000
RANGE OF ID	3909	BELOW CRITERION	4000
RANGE OF ACQUISITION	3389	BELOW CRITERION	5000
RANGE OF LOCK-ON	2611	BELOW CRITERION	4000
RANGE OF FIRE	1760	BELOW CRITERION	2000

SPECIAL GUN SYSTEM LFX SCORES		MEANS
NUMBER OF ROUNDS ON TARGET	=	
MISS DISTANCE	=	
HIT POINT	=	

PASS-FAIL DETERMINATION

****

SPM	SCORE	STATUS	CRITERIA
% CORRECT ID	100	PASSING	70
% AC DESTROYED	100	PASSING	60
% FRIENDS ENG	0	PASSING	30
% HOSTILES ENG	100	PASSING	75
% FRIENDS CORRECT ID	100	PASSING	70
% HOSTILES CORRECT ID	100	PASSING	75
% FRATRICIDES	0	PASSING	25
% ATTRITION	100	PASSING	45

SPECIAL GUN SYSTEM LFX SCORES		MEANS
AVERAGE NUMBER OF ROUNDS ON TARGET	=	
AVERAGE NUMBER OF ROUNDS PER BURST	=	
AVERAGE NUMBER OF TARGETS KILLED	=	

CREW: 01 03/03/88 14:56:26

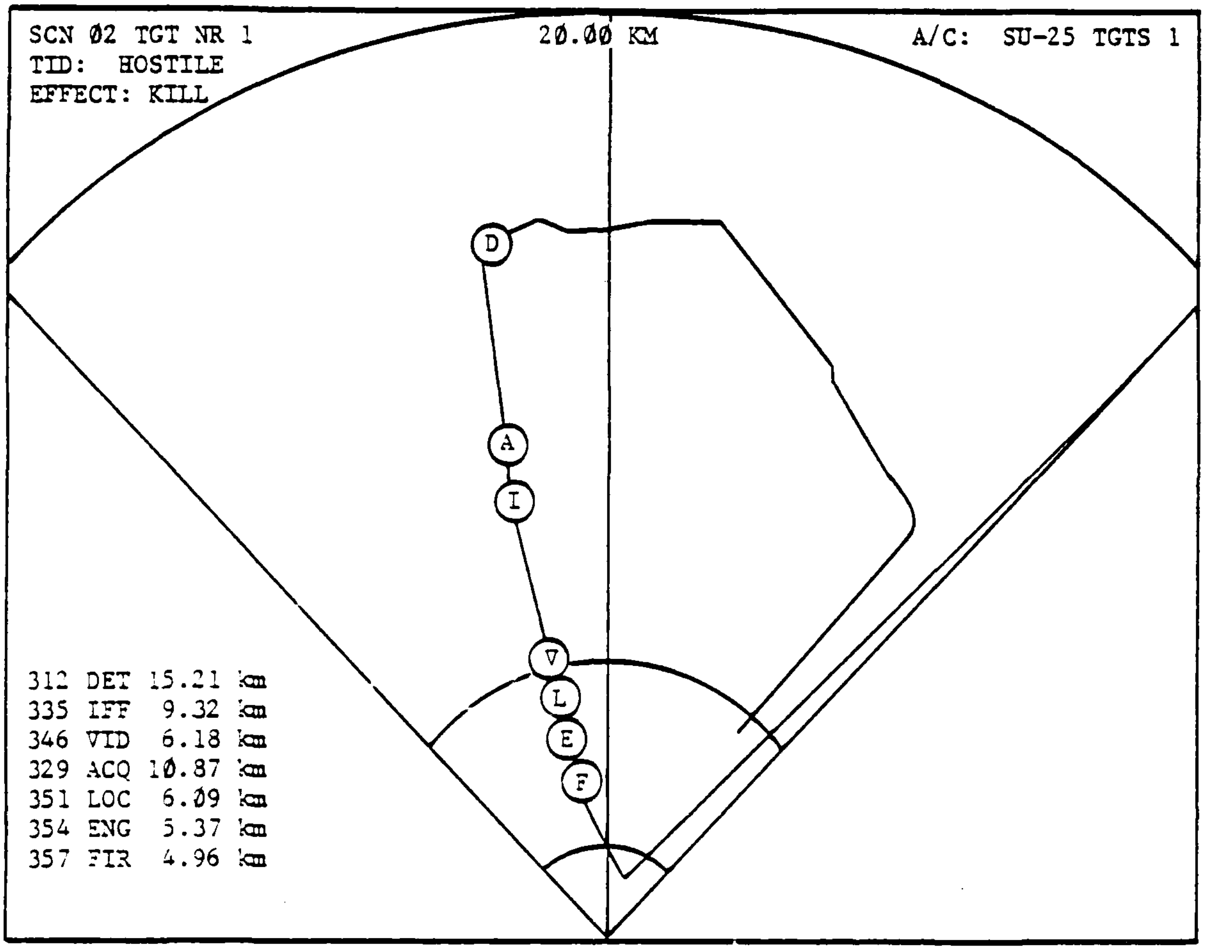

Figure 6
Fixed Wing Scenario Feedback Screen

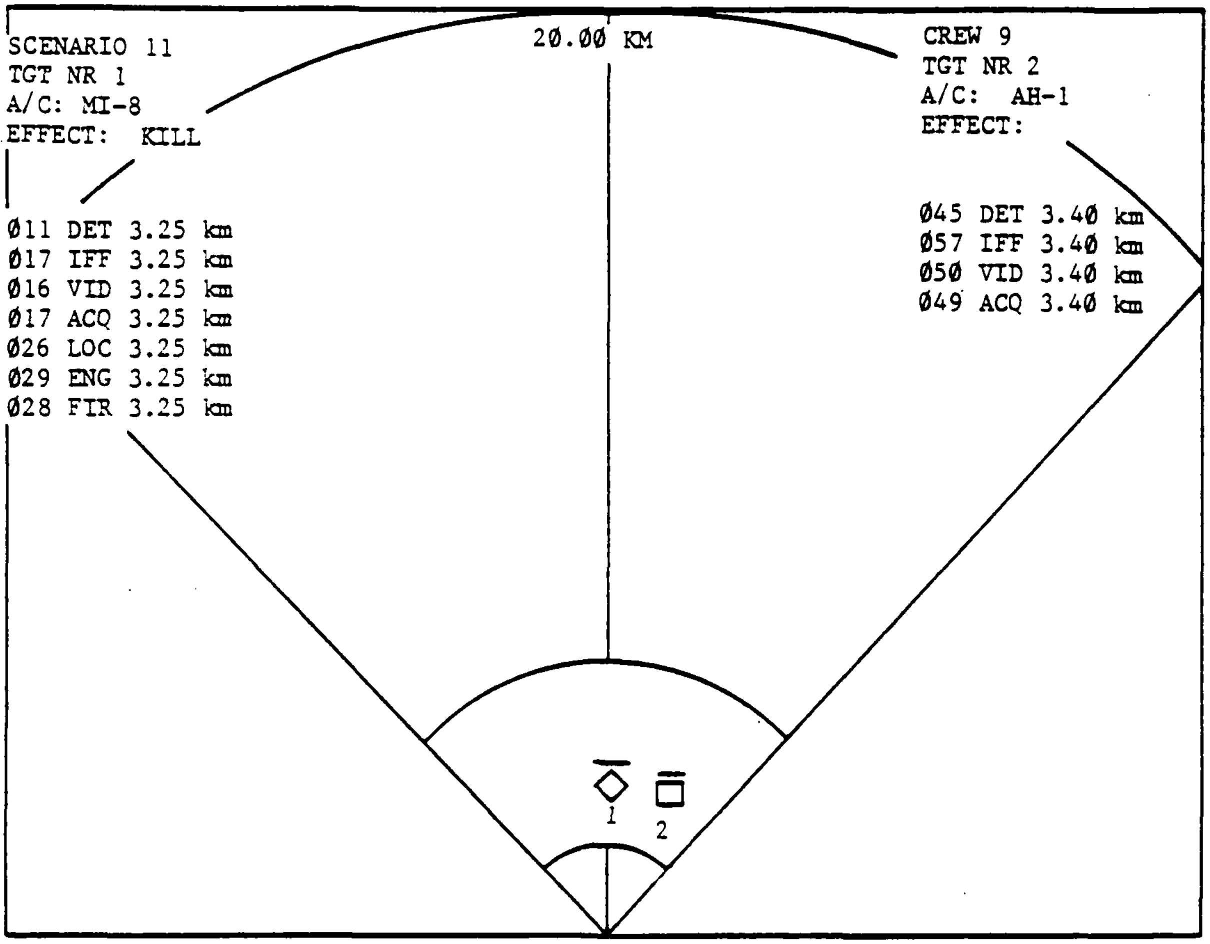

Figure 7
Rotary Wing Scenario Feedback Screen

Determination of Scenario Difficulty Factors

Requirement: To determine the difficulty of a scenario based on target, soldier, and enviromental factors.

Procedures: Difficulty criteria were identified based on air defense research findings and the human factors literature. The level of difficulty criteria are given in Appendix B. Each difficulty factor was assigned a relative weight, based upon its expected effect on performance. Three sources of data were utilized for obtaining the difficulty scaling factors and ascribing relative weights to them. These were: subject matter experts, the available literature, and previous RADES data.

The difficulty level for each scenario in a standard set of 20, was derived by each expert judge, and across expert judges. Agreement among the experts was good regarding the factors considered important for establishing scenario performance difficulty levels. In rating the difficulty of the scenarios, interrater reliability was also good as demonstrated by Spearman correlations (range of r-values = .17 to .92; average r-value = .68, $p < .001$). Subject matter experts were members of the research team from ARI and SAIC.

Data (SPM and TPM) obtained from field test administrations of the standard set of scenarios were established as baseline parameters of performance. The difficulty criteria weights were then used to predict variations in performance. Performance variations were consistent with the difficulty criteria weights ascribed to the scenarios.

The method used to derive scenario difficulty scores was based on classic decision analysis logic. The process began with the identification of difficulty factors. These factors were ascribed relative weights by subject matter experts based on their evaluation of how performance was affected by the factors. Each factor was comprised of several subfactors which related to specific scenario conditions characteristic of the factors under which they were categorized. These subfactors were ascribed values, which, when multiplied by the associated factor weight, resulted in a difficulty score for that factor. The factor score was therefore dependent on the subfactor which was relevant to the scenario being scaled. A total difficulty score was derived for each scenario based on the sum of all difficulty scaling factor scores. Scenario difficulty levels (1 through 5, or low to high) were assigned to each scenario which reflected the relative differences between scenario difficulty scores.

Findings: Given that interrater reliability was good, ratings accounting for the highest variance in performance (R^2) were employed to ascribe scenario difficulty. These difficulty predictor weights were subsequently used to assign performance difficulty levels to the 200 scenarios developed during this effort (See Appendix A).

Scenario Field Testing

Requirement: To subject the draft scenarios, scenario difficulty indices, task and summary performance measures, SPM and TPM cut-off values, test conditions, and scoring system to empirical test and evaluation on representative samples of soldiers and weapons.

Procedures: Ten Stinger teams from the Stinger Platoon, Headquarters and Headquarters Troop, Third Armored Cavalry Regiment stationed at Fort Bliss, Texas participated in the study. The test was conducted at White Sands Missile Range, White Sands, New Mexico, in desert terrain, in clear weather, under daylight conditions, during the month of January of 1988, using the RADES instrumented testbed. Each Stinger team was exposed to as many as twenty scenarios. Each scenario presented either flying, fixed-wing (FW) and/or pop-up, rotary-wing (RW) targets, either in single or multi-target presentations. Scenario specifications are provided in Table 17. The scenario sequences executed for each team are given in Table 18. Each Stinger team (consisting of a team chief and gunner) was given an early warning twenty seconds prior to each scenario presentation. Cuing information was not provided. Team chiefs were given binoculars, which they used for aircraft identification purposes only.

Task performance measures (TPM) included times and ranges associated with target detection, interrogation, acquisition, identification, lock-on, superelevation, and fire. Summary performance measures (SPM) included correctness of identification, engagement effectiveness (i.e., kill or miss), hostile attrition, hostile ordnance delivery prevention, and fratricide. Dependent variables used are listed and described in Table 19.

Table 17
Standardized Scenario Set

SCEN NO.	TYPE	INTENT	AIRCRAFT	AZIMUTH	ASPECT	PATTERN/ RANGE	PRESENT. ORDER	DUR.	LOD
1	FW	F	A10	12	0	A			MH
2	FW	F	F16	1	45	B			MH
3	FW	F	F111	10	90	C			M
4	FW	H	MIG27	12	0	A			MH
5	FW	H	SU25	11	45	B			MH
6	FW	H	SU24	2	90	C			M
7	RW	F	UH60	11	90	3		25	L
8	RW	F	CH3	12	45	5		25	ML
9	RW	H	MI? (HOKUM)	11	90	3		25	L
10	RW	H	MI8	12/11	45	7/5	SEQUEN	10	ML
11	RW	H	MI24	12/1	0	5/3	SEQUEN	10	L
12	RW	F	AH1/UH1	11/1	45	3	SEQUEN	25	L
13	RW	H	MI8/MI24	12/1	45	7/5	SEQUEN	25	ML
14	RW	F/H	CH3/MI8	11/1	45	5	SIMULT	40	ML
15	RW	H	MI8/MI28/MI24	11/12/1	45	3/5/5	SIMULT	50	M
16	RW	F/H/H	AH1/MI24/MI28	11/12/1	90	3/7/5	SIMULT	40	M
17	RW	F/H/F	CH3/MI28/UH1	11/12/1	45	5/5/3	SIMULT	40	M
18	Both	F/H	A7/MI24	12/1	0/45	A/3	SIMULT	30	H
19	Both	H	SU17/MI?/MI28	11/12/1	45/45/0	B/5/3	SIMULT	60	H
20	Both	H/F/H	SU25/UH60/MI8	12/11/1	0/45/45	A/5/5	SIMULT	40	H

Difficulty levels: H=high, M=medium, L=low
FW Patterns: A = ingress at 0 degrees aspect; B = diagonal ingress at 45 degrees aspect; C = crossing pattern at 90 degrees aspect

Table 18
Scenario Presentation Sequence

TEAMS	SCENARIO SEQUENCE
1,2,3,4	D,9,11,13,18,10,3,8,16,2,20,5,14,7,6,15,4,17,1,12
5,6,7	D,15,7,14,17,4,11,5,12,20,8,6,16,18,3,9,10,1,13,19,2
8,9,10	D,1,12,10,9,2,13

KEY: D = Dummy or practice trial

Table 19
Dependent Variables

CODE	TITLE or DESCRIPTION	DUTY	INTERPRETATION
IDCOR	Correctness of Identification	TL	Number of correct identifications divided by number of targets identified
FIRED	Weapon Fired	G	Number of weapon fires divided by number of targets presented.
EFFECT	Target Hit or Missed	G	Number of targets killed divided by number engaged
FRAT	Fratricide	BOTH	EFFECT on Friendlies
ATTRIT	Attrition	BOTH	EFFECT on Hostiles
ORD	Ordnance Prevention	BOTH	Number of hostiles delivering ordnance divided by number presented
RDET	Range of Detection	TL or G	The slant range from the weapon to the target when the event took place; greater ranges usually indicate better performance for detection and identification but not always for the other events (target can be inbound or outbound). Range is relevant for fixed-wing targets only since rotary-wing targets simply pop-up from a static position. Ranges are in full scale kilometers.
RID	Range of Identification	TL	
RACQ	Range of Initial Acquisition	G	
RIFF	Range of Interrogation	G	
RLOCK	Range of Lock-on	G	
RFIRE	Range of Weapon Fire	G	

Table 19 (Continued)
Dependent Variables

CODE	TITLE or DESCRIPTION	DUTY	INTERPRETATION
TDET	Time of Detection	TL or G	Based on seconds after target availability; availability begins when visual line-of-sight is achieved on the first RW target
TID	Time of Identification	TL	Time interval between Detection and Identification
TACQ	Time of Initial Acquisition	G	Time interval between Detection and Acquisition
TIFF	Time of Interrogation	G	Time interval between Detection and IFF
TLOCK	Time of Lock-On	G	Time interval between Acquisition and Lock-On
TFIRE	Time of Weapon Fire	G	Time interval between Lock-On and Fire
TTOT	Total Engagement Time	BOTH	Time interval between Detection and Fire
THAND	Time of Handoff	BOTH	Time interval between Command to Engage and Weapon Fire

KEY: TL = Team Leader; G = Gunner

Findings: Table C1 (See Appendix C) depicts the average performance, number of cases, and the variability (standard deviation) across teams for each scenario. These data will be used as a benchmark in estimating future performance on this same set of 20 scenarios, or an equivalent sample of like-difficulty scenarios. It is anticipated that future performance on these scenarios will be approximately equal for soldiers with similar experience and ability, and that performance will fall within reasonable boundaries (90 percent confidence interval) established in this table. Data contained in Table C1 are self explanatory and therefore require no detailed elaboration here.

Tables 20 and 21 provide the summary performance of soldiers according to scenario conditions across all observations. As shown in Table 20, soldiers accurately identified friendly helicopters 45% of the time and hostile helicopters 71% of the time. Friendly FW were accurately identified 69% and hostile FW 85% of the time. The friendly fixed wing F-16 and the friendly rotary wing CH-3 were frequently misidentified. Attrition rates on hostile aircraft were 70% for FW and 41% for RW.

Further, performance effectiveness (identification correctness: IDCOR; and engagement effect: EFFECT) decreased in multiple RW target scenarios (See Table 21). Identification accuracy and engagement effectiveness (EFFECT, ATTRIT, and ORD) decreased with increased workload. Thus, aircraft model type, intent, and the number of targets (workload level), were deemed important factors for assessing scenario difficulty level.

Table 22 shows the relationship between RW elevation, offset from PTL, and presentation aspect on measures of engagement performance. Data are summed over all teams and targets for all relevant scenarios. Improved target visibility, as measured by RW target elevation, offset, and aspect, resulted in improved performance on both TPM and SPM. Target visibility was a major factor used in assessing scenario difficulty. See also Table C1 for information on how performance varied in terms of target range, aspect, and model type.

Tables 23 and 24 present the results of statistical analyses which show that observed engagement performance varied as a function of scaled scenario difficulty level. Difficulty level weights were assigned to scenarios by subject matter experts according to criteria known to affect engagement performance, such as target visibility, workload, intent, range, and model type. (See Appendix B). Generally, on more difficult scenarios, troops required more time for target identification, they locked-onto and fired at identified hostile targets later, and they required more time for a complete engagement (detect to fire).

Table 20
Summary Performance Results by Target Type and Intent

VARIABLE	TYPE	INTENT	MEAN	SD	N
IDCOR	FW	Friendly	.69	.47	26
	FW	Hostile	.85	.36	27
	FW	Both	.77	.46	53
	RW	Friendly	.45	.50	62
	RW	Hostile	.71	.46	133
	RW	Both	.62	.49	195
	Both	Both	.66	.48	248
FRAT	FW	Friendly	.08	.27	26
	RW	Friendly	.32	.47	62
	Both	Friendly	.25	.44	88
ATTRIT	FW	Hostile	.70	.47	27
	RW	Hostile	.41	.49	131
	Both	Hostile	.46	.50	158

NOTE: Data are based on all applicable scenarios and teams.

Table 21
Summary Performance Results by Each Subsequent RW Target Worked

VARIABLE	TARGET	MEAN	SD	N
IDCOR	1	.72	.45	138
	2	.62	.49	80
	3	.43	.50	30
	All	.66	.48	248
EFFECT	1	.77	.43	81
	2	.58	.50	48
	3	.33	.49	14
	All	.66	.48	144
FRAT	1	.62	.42	59
	2	.40	.50	20
	3	.11	.33	9
	All	.25	.44	88
ATTRIT	1	.62	.49	79
	2	.34	.48	58
	3	.19	.40	21
	All	.46	.50	158
ORD	1	.57	.50	79
	2	.97	.18	60
	3	.95	.22	21
	All	.77	.42	160

NOTE: Data are based on all applicable scenarios and teams (excluding second target of sequential target scenarios).

Table 22
Effects of RW Scenario Variations on Performance
(Significant Pearson Correlations)

INDEPENDENT VARIABLE	DEPENDENT VARIABLE	CORR.	N	PROB.
RW Elevation Above Mask (.5 to 3.5 degrees; mean = 1.5)	TDET	-.33	173	.000
	TID*	-.34	168	.000
	TTOT	-.19	115	.019
	EFFECT	-.15	114	.057
	ORD	-.28	179	.000
RW Offset From PTL (1 to 55 degrees; mean = 15.2)	TDET	.18	164	.009
	TID*	.22	160	.003
	TID	.16	159	.019
	TACQ	.21	133	.007
	TTOT	.19	109	.022
RW Aspect/ Orientation (0, 45 or 90 degrees)	TDET	-.13	174	.040
	TID	-.12	171	.067
	TLOCK	-.15	116	.052
	IDCOR	.12	195	.050
	ORD	-.12	195	.041

* = Raw TID; time from availability to ID.
N = Number of RW target presentations.

Table 23
Results of t Test Comparisons of Performance by Difficulty Level (Two-Tailed Test Using Separate Sample Variances)

COMPARISON	TYPE	VARIABLE	MEAN	SD	N	T	DF	PROB
H vs M	FW	TID	21.9;13.0	11.7;3.6	16;14	2.9	18.2	.009
H vs M	FW	RLOCK	3.7; 5.7	1.7;0.5	10; 9	3.5	10.4	.006
H vs M	FW	RFIRE	3.0; 5.8	1.4;0.6	11; 8	5.9	13.7	.000
H vs M	FW	TTOT	29.2;20.5	12.9;3.8	11; 8	2.1	12.3	.056
MH vs M	FW	TID	17.2;13.0	6.5;3.6	20;14	2.4	30.8	.024
MH vs M	FW	RLOCK	4.3; 5.7	1.9;0.5	10; 9	2.1	10.2	.058
MH vs M	FW	RFIRE	3.8; 5.8	2.1;0.6	10; 8	2.8	10.6	.017
MH vs M	FW	TTOT	25.3;20.5	7.7;3.8	10; 8	1.7	13.6	.108
M vs L	RW	TTOT	11.1; 8.9	3.8;3.8	37;20	2.1	39.0	.046
MH vs M	Both	TID	17.2; 7.1	6.5;4.4	20;70	6.5	24.3	.000
MH vs M	Both	TTOT	25.3;11.8	7.7;5.8	10;49	5.2	11.1	.000
MH vs ML	Both	TID	17.2; 5.6	6.5;2.6	20;49	7.7	21.6	.000
MH vs ML	Both	TTOT	25.3;11.1	7.7;3.8	10;37	5.7	10.2	.000
H vs M	Both	TID	12.8; 7.1	11.5;4.4	37;70	2.9	41.7	.006
H vs M	Both	TFIRE	4.5; 2.5	5.3;1.9	29;43	2.0	32.9	.054
H vs M	Both	TTOT	19.9;11.8	12.8;5.8	29;49	3.2	34.8	.003

N = Number of applicable FW or RW target presentations.

Table 24
Relationship Between Difficulty Level and Performance (Significant Kendall and Spearman Correlations)

TYPE	DEPENDENT VARIABLE	KENDALL'S TAU	N	PROB	SPEARMAN'S RHO	N	PROB
FW	TID	.85	9	.002	.94	9	.000
FW	RFIRE	-.91	4	.035	-.95	4	.026
FW	TTOT	-.54	6	.075	-.74	6	.046
FW	FRAT	.80	5	.039	.88	5	.023

N = Number of Stinger teams for which applicable data were available.

There were exceptions to the above. For example, a scenario with a crossing FW pattern was determined to be easier than one with an ingressing FW pattern because the target was easier to detect and identify, and was more frequently identified correctly. However, it was also available for a shorter period of time, forcing the soldiers to complete the engagement sooner. Further, although more workload implied more difficulty, sometimes it resulted in shorter engagement times since the soldiers were rushed. Therefore, both an easy and a difficult scenario was characterized by shorter engagement times, depending upon the conditions. Increasing the number of targets often resulted both in higher hostile attrition rates and higher fratricide rates, since the soldiers were inclined to engage everything that appeared to pose a threat. As a rule, however, increases in difficulty resulted both in decreased engagement efficiency and decreased engagement effectiveness.

Scenario difficulty in this study, as measured by performance effectiveness and efficiency, was primarily attributed to:

- Target characteristics
  - Model Size
  - Intent
  - Type (RW versus FW)

- Visibility conditions
  - Target Elevation
  - Target Offset
  - Target Aspect
  - Target Speed

- Workload level
  - Number of Targets

This test empirically validated many of the difficulty factors used by the experts to ascribe weights to scenarios. Studies such as this enable researchers to estimate the difficulty of air defense scenarios from empirical evidence. The difficulty scaling technique used to assess the difficulty level of the 200 scenarios presented in Appendix A was based upon this empirical evidence.

Determination of SPM and TPM Cut-off Scores

Requirement: To establish SPM score cut-off values which sort SHORAD crews, teams, and operators into qualified and unqualified groups. It was required that SPM cut-off values be achievable, valid, reliable, practical, and economic to administer. A second requirement was to establish TPM score cut-off values which identified deficient part-task performance and which indicated the sources of failure to qualify.

Procedures: It was acknowledged from the onset of the present research that only the USAADASCH, Directorate of Training and Doctrine (DOTD), Fort Bliss, is chartered to, and proponent for, setting range qualification standards. Therefore the present research was limited to analysis, interpretation, and recommendation of SPM and TPM cut-off scores.

Analysts examined the results of the RADES meta-analysis, field test data, literature on threat and friendly air operations, airspace management, command, control and communications, and weapons capabilities and limitations. Then analysts assisted ARI in establishing realistic SPM cut-off scores, and in adapting the draft training and qualification scenarios to the current tactical Short Range Air Defense picture. It must be noted that data from the Vulcan or PIVADS weapons were not available. It was therefore assumed that the criteria would need to be adjusted to accomodate close-range weapons such as these.

Draft cut-off scores were subjected to empirical field testing using the RADES testbed. The field tests were conducted to insure that the current SHORAD soldier population could attain the performance standards, and that those standards could be reliably, practically, and economically administered. The Stinger test described earlier helped to serve this purpose, and verified that these requirements were met.

Findings: Table 25 provides the recommended SPM cut-off scores established by the present program of research. Table 26 provides the recommended TPM cut-off scores which are to be used in diagnosing the sources of crew, team, and operator failures to qualify on SPM. It should be noted that all TPM ranges reflect incoming (not outgoing) FW targets.

Table 25
SPM Cutoff Values Estimated From RADES Research Results

FIXED WING			ROTARY WING		
SPM	LOD	VALUE	SPM	LOD	VALUE
Identity Correctness (IDCOR)	H M L	70% 75% 80%	Identity Correctness (IDCOR)	H M L	70% 75% 80%
Friends Identified (FIDCOR)	H M L	70% 75% 80%	Friends Identified (FIDCOR)	H M L	70% 75% 80%
Hostiles Identified (HIDCOR)	H M L	75% 80% 85%	Hostiles Identified (HIDCOR)	H M L	75% 80% 85%
Friends Engaged (FENG)	H M L	30% 25% 20%	Friends Engaged (FENG)	H M L	30% 25% 20%
Hostiles Engaged (HENG)	H M L	75% 80% 85%	Hostiles Engaged (HENG)	H M L	75% 80% 85%
Friendly Kills (FRAT)	H M L	25% 20% 15%	Friendly Kills (FRAT)	H M L	25% 20% 15%
Hostile Kills (ATTRIT)	H M L	45% 60% 75%	Hostile Kills (ATTRIT)	H M L	55% 70% 80%
Engaged/ Destroyed (EFFECT)	H M L	60% 75% 90%	Engaged/ Destroyed (EFFECT)	H M L	75% 85% 95%
Ordnance Released (ORD)	H M L	95% 75% 30%	Ordnance Released (ORD)	H M L	95% 75% 30%

LOD = Level of Difficulty

Table 26
TPM Cutoff Values Estimated From RADES Research Results

FIXED WING			ROTARY WING		
TPM	LOD	VALUE	TPM	LOD	VALUE
Detect (RDET)	H	8.0 km	Detect (TDET)	H	10.0 sec
	M	11.0 km		M	6.0 sec
	L	14.0 km		L	4.0 sec
Acquire (RACQ)	H	5.0 km	Acquire (TACQ)	H	6.0 sec
	M	6.0 km		M	5.0 sec
	L	7.0 km		L	4.0 sec
Identify (RID)	H	4.0 km	Identify (TID)	H	9.0 sec
	M	6.0 km		M	7.0 sec
	L	8.0 km		L	5.0 sec
Engage (RENG)	H	3.5 km	Engage (TENG)	H	2.0 sec
	M	5.5 km		M	1.0 sec
	L	7.5 km		L	1.0 sec
Lock-On (RLOCK)	H	4.0 km	Lock (TLOCK)	H	6.0 sec
	M	5.0 km		M	4.0 sec
	L	6.0 km		L	2.0 sec
Fire (RFIRE)	H	2.0 km	Fire (TFIRE)	H	5.0 sec
	M	4.0 km		M	3.0 sec
	L	5.0 km		L	2.0 sec
			Total (TTOT)	H	15.0 sec
				M	12.0 sec
				L	8.0 sec

LOD = Level of Difficulty

It can be seen, when comparing the Stinger test results cited earlier (Table C1 and Table 20) to the criteria established a-priori (Tables 25 and 26) that soldiers met some of the criteria but failed to meet others. For example, while correctness of target identification was often within tolerance limits, ordnance prevention and fratricide rates often were not. This is consistent with the observation made earlier that many of the system and operator performance standards were not currently being achieved. This may be due in part to the fact that the TPM and SPM estimates were based on cued trials, and the Stinger test results were based on non-cued trials. The decision to base the criteria on cued trials was reached after the Stinger test was conducted. Overall, however, the Stinger test results cited earlier were consistent with the TPM and SPM estimates. For example, event ranges for moderately difficult FW scenarios for detection, identification, acquire, and fire were estimated at about 11, 6, 6, and 4 kilometers, respectively. These estimated ranges were similar to those obtained in the Stinger test. Further, these events for low difficulty RW scenarios were estimated at about 4, 5, 4, and 2 seconds, respectively. Again these estimated values were consistent with performance in the Stinger test.

SPM and TPM cut-off scores were determined as a function of scenario difficulty. Definition of meaningful SPM cutoff levels was accomplished as a natural by-product of the meta-analysis, and the RADES experiment described earlier. TPM cut-off scores were established in the same way. It is currently anticipated, however, that TPM cut-off scores will be used solely for diagnosing the sources of SPM failures to qualify, and will not be the basis for crew, team, or operator pass or fail determinations.

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APPENDIX A

RTS SCENARIO LIBRARY AND TARGET SPECIFICATIONS

Scen No.	No. Targ	Type	Intent	Aircraft Model	Clock Azimuth	Degrees Aspect	Pattern /Stand	Pres. Order	Seconds Avail.	Diffic Level
1	1	FW	F	1	10	90	A	--	--	M
2	1	FW	F	1	11	45	B	--	--	MH
3	1	FW	F	1	12	0	C	--	--	MH
4	1	FW	F	1	1	45	D	--	--	MH
5	1	FW	F	1	2	90	E	--	--	M
6	1	FW	F	2	10	90	A	--	--	M
7	1	FW	F	2	11	45	B	--	--	MH
8	1	FW	F	2	12	0	C	--	--	MH
9	1	FW	F	2	1	45	D	--	--	MH
10	1	FW	F	2	2	90	E	--	--	M
11	1	FW	F	3	10	90	A	--	--	M
12	1	FW	F	3	11	45	B	--	--	MH
13	1	FW	F	3	12	0	C	--	--	MH
14	1	FW	F	3	1	45	D	--	--	MH
15	1	FW	F	3	2	90	E	--	--	M
16	1	FW	H	4	10	90	A	--	--	M
17	1	FW	H	4	11	45	B	--	--	MH
18	1	FW	H	4	12	0	C	--	--	MH
19	1	FW	H	4	1	45	D	--	--	MH
20	1	FW	H	4	2	90	E	--	--	M
21	1	FW	H	5	10	90	A	--	--	M
22	1	FW	H	5	11	45	B	--	--	MH
23	1	FW	H	5	12	0	C	--	--	MH
24	1	FW	H	5	1	45	D	--	--	MH
25	1	FW	H	5	2	90	E	--	--	M
26	1	FW	H	6	10	90	A	--	--	M
27	1	FW	H	6	11	45	B	--	--	MH
28	1	FW	H	6	12	0	C	--	--	MH
29	1	FW	H	6	1	45	D	--	--	MH
30	1	FW	H	6	2	90	E	--	--	M
31	2	FW	F	1,2	11	45	B	Sequen	30	H
32	2	FW	F	2,3	11,12	45,0	D,C	Sequen	30	H
33	2	FW	F	3	12	0	C	Sequen	30	H
34	2	FW	H	4,5	1	45	B	Sequen	30	H
35	2	FW	H	5,6	11,12	45,0	D,C	Sequen	30	H
36	2	FW	H	6	12	0	C	Sequen	30	H
37	2	FW	F,H	3,6	11,1	45	B,D	Sequen	30	H
38	2	FW	H,F	6,3	1,11	45	D,B	Sequen	30	H
39	2	FW	F,H	2,4	12	0	C	Sequen	30	H
40	2	FW	H,F	4,2	1	90	E	Sequen	30	MH
41	2	FW	F	1	12	0	C	Simult	--	MH
42	2	FW	H	5	12	0	C	Simult	--	MH
43	2	FW	F	1,3	12,2	0,90	C,E	Simult	--	XH
44	2	FW	F	2	10,12	90,0	A,C	Simult	--	XH
45	2	FW	H	4,6	12,2	0,90	C,E	Simult	--	XH

Scen No.	No. Targ	Type	Intent	Aircraft Model	Clock Azimuth	Degrees Aspect	Pattern /Stand	Pres. Order	Seconds Avail.	Diffic Level
46	2	FW	H	4	10,12	90,0	A,C	Simult	--	XH
47	2	FW	F,H	2,5	11,1	45	B,D	Simult	--	XH
48	2	FW	H,F	6,1	10,2	90	A,E	Simult	--	XH
49	2	FW	F,H	2,5	10,11	90,45	A,B	Simult	--	XH
50	2	FW	H,F	6,1	1,2	45,90	D,E	Simult	--	XH
51	1	RW	F	11	11	45	1	--	25	L
52	1	RW	F	11	12	90	4	--	25	L
53	1	RW	F	11	1	0	5	--	25	L
54	1	RW	F	11	1	45	6	--	25	ML
55	1	RW	F	12	11	0	1	--	25	L
56	1	RW	F	12	11	90	1	--	25	L
57	1	RW	F	12	12	45	3	--	25	L
58	1	RW	F	12	1	45	6	--	25	ML
59	1	RW	F	13	11	45	2	--	25	ML
60	1	RW	F	13	12	45	4	--	25	ML
61	1	RW	F	13	1	0	5	--	25	L
62	1	RW	F	13	11	90	6	--	25	L
63	1	RW	F	14	11	0	2	--	25	ML
64	1	RW	F	14	12	45	3	--	25	L
65	1	RW	F	14	12	90	4	--	25	ML
66	1	RW	F	14	1	45	5	--	25	L
67	1	RW	H	15	11	45	1	--	25	L
68	1	RW	H	15	11	45	2	--	25	ML
69	1	RW	H	15	12	0	3	--	25	L
70	1	RW	H	15	1	90	6	--	25	L
71	1	RW	H	16	11	0	1	--	25	L
72	1	RW	H	16	12	45	3	--	25	L
73	1	RW	H	16	12	90	4	--	25	L
74	1	RW	H	16	1	45	6	--	25	ML
75	1	RW	H	17	11	45	1	--	25	L
76	1	RW	H	17	12	0	3	--	25	L
77	1	RW	H	17	1	45	5	--	25	L
78	1	RW	H	17	1	90	6	--	25	L
79	1	RW	H	18	11	90	2	--	25	L
80	1	RW	H	18	11	45	2	--	25	ML
81	1	RW	H	18	12	45	4	--	25	ML
82	1	RW	H	18	1	0	5	--	25	L
83	2	RW	F	11	12	0	4,2	Sequen	15	L
84	2	RW	F	13	12,1	90	4,6	Sequen	15	L
85	2	RW	F	14	11,12	45	1,4	Sequen	15	L
86	2	RW	F	13,12	1,11	45	6,1	Sequen	15	L
87	2	RW	H	15	11	0	1,2	Sequen	15	L
88	2	RW	H	16	12,1	90	4,6	Sequen	15	L
89	2	RW	H	17	1,12	45	5,4	Sequen	15	L
90	2	RW	H	15,18	11,1	45	1,6	Sequen	15	L
91	2	RW	F,H	12,18	11,1	0	1,5	Sequen	15	L
92	2	RW	H,F	18,12	11,1	0	2,6	Sequen	15	ML
93	2	RW	F,H	11,17	12	0	4,3	Sequen	15	ML

Scen No.	No. Targ	Type	Intent	Aircraft Model	Clock Azimuth	Degrees Aspect	Pattern /Stand	Pres. Order	Seconds Avail.	Diffic Level
94	2	RW	H,F	16,14	12	45	4,3	Sequen	15	L
95	2	RW	F,H	13,15	11,1	90	2,6	Sequen	15	L
96	2	RW	H,F	12,16	11,1	0,45	1,6	Sequen	15	L
97	2	RW	F	11	11,1	0	1,5	Simult	40	ML
98	2	RW	F	12,13	11,1	90	2,6	Simult	40	ML
99	2	RW	F	11,14	12	45	4,3	Simult	40	ML
100	2	RW	F	12,13	11,12	0,45	1,4	Simult	40	ML
101	2	RW	H	17	11,1	0	1,5	Simult	40	ML
102	2	RW	H	18,17	11,1	90	2,6	Simult	40	ML
103	2	RW	H	16,15	12	45	4,3	Simult	40	ML
104	2	RW	H	18,15	11,12	0,45	1,4	Simult	40	ML
105	2	RW	F,H	12,18	11,1	0	1,5	Simult	40	ML
106	2	RW	F,H	11,16	11,12	45	4,6	Simult	40	ML
107	2	RW	F,H	13,17	11,1	45,0	2,5	Simult	40	ML
108	2	RW	F,H	12,18	12	90	4,2	Simult	40	ML
109	2	RW	H,F	15,14	1	45	6,5	Simult	40	ML
110	2	RW	H,F	15,13	11,1	45	2,6	Simult	40	ML
111	2	RW	H,F	17,11	11,12	0,45	1,4	Simult	40	ML
112	2	RW	H,F	16,12	12,1	90,45	4,6	Simult	40	ML
113	3	RW	F	11,14,13	12,1,11	45	4,5,2	Sequen	15	ML
114	3	RW	F	13,14,12	11,12,11	45	2,4,1	Sequen	15	ML
115	3	RW	H	18,15,17	12,11,1	45	4,2,5	Sequen	15	ML
116	3	RW	H	16,18,17	1,12,1	45	6,4,5	Sequen	15	ML
117	3	RW	F,H,F	13,16,12	11,1,12	45	2,5,3	Sequen	15	ML
118	3	RW	F,H,F	11,18,12	11,12,1	90	1,4,6	Sequen	15	ML
119	3	RW	F,H,F	14,16,13	12,11,1	0	4,1,5	Sequen	15	M
120	3	RW	F,F,H	13,12,15	12,11,11	0,45,45	4,1,2	Sequen	15	ML
121	3	RW	H,F,F	16,11,11	12,1,1	45,45,0	4,6,5	Sequen	15	ML
122	3	RW	H,F,H	17,12,15	1,12,11	45	6,3,2	Sequen	15	ML
123	3	RW	H,F,H	18,11,17	11,12,1	90	2,4,5	Sequen	15	ML
124	3	RW	H,F,H	18,14,15	1,12,11	0	5,4,2	Sequen	15	M
125	3	RW	F,H,H	14,18,17	12,11,11	0,45,45	4,1,2	Sequen	15	ML
126	3	RW	H,H,F	16,17,13	12,1,1	45,45,0	4,6,5	Sequen	15	ML
127	3	RW	F	13,14,11	11,12,1	45	2,4,6	Simult	60	M
128	3	RW	F	12,14,13	11,12,1	45	1,3,5	Simult	60	M
129	3	RW	F	12,11,12	11,12,1	0,90,45	1,4,6	Simult	60	M
130	3	RW	F	14,11,13	11,1,1	90,45	2,5,6	Simult	60	M
131	3	RW	H	15,16,17	11,12,1	45	2,4,6	Simult	60	M
132	3	RW	H	17,15,18	11,12,1	45	1,3,5	Simult	60	M
133	3	RW	H	16,18,16	11,12,1	0,90,45	1,4,6	Simult	60	M
134	3	RW	H	18,17,16	11,1,1	90,45	2,5,6	Simult	60	M
135	3	RW	F,H,F	11,17,11	11,12,1	0	1,3,5	Simult	60	M
136	3	RW	F,H,F	12,16,13	1,12,11	45	6,4,2	Simult	60	M
137	3	RW	F,H,F	14,15,13	12,1,11	90	4,6,2	Simult	60	M
138	3	RW	F,F,H	14,13,17	11,12,1	0,90,45	2,4,5	Simult	60	M
139	3	RW	F,F,H	12,11,15	11,12,1	0,45,0	1,4,6	Simult	60	M
140	3	RW	H,F,F	15,12,13	11,12,1	0,90,45	2,3,6	Simult	60	M
141	3	RW	H,F,F	16,14,11	11,12,1	45,0,90	1,3,6	Simult	60	M

Scen No.	No. Targ	Type	Intent	Aircraft Model	Clock Azimuth	Degrees Aspect	Pattern /Stand	Pres. Order	Seconds Avail.	Diffic Level
142	3	RW	F,F,H	11,13,15	11,1,11	45	1,5,2	Simult	60	M
143	3	RW	H,F,F	17,14,12	1,12,1	45	5,4,6	Simult	60	M
144	3	RW	H,F,H	17,12,17	11,12,1	0	1,3,5	Simult	60	M
145	3	RW	H,F,H	16,11,15	1,12,11	45	6,4,2	Simult	60	M
146	3	RW	H,F,H	16,11,15	12,1,11	90	4,6,2	Simult	60	M
147	3	RW	H,H,F	18,16,12	11,12,1	0,90,45	2,4,5	Simult	60	M
148	3	RW	H,H,F	15,16,13	11,12,1	0,45,0	1,4,6	Simult	60	M
149	3	RW	F,H,H	14,17,15	11,12,1	0,90,45	2,3,6	Simult	60	M
150	3	RW	F,H,H	12,15,17	11,12,1	45,0,90	1,3,6	Simult	60	M
151	3	RW	H,H,F	17,18,13	11,1,11	45	1,5,2	Simult	60	M
152	3	RW	F,H,H	11,18,16	1,12,1	45	5,4,6	Simult	60	M
153	2	MIX	F	1,13	12	0,45	C,4	Simult	40	H
154	2	MIX	F	2,11	1,11	45	D,1	Simult	40	H
155	2	MIX	F	3,12	12,1	0,90	C,6	Simult	40	H
156	2	MIX	F	2,14	10,1	90,45	A,5	Simult	40	H
157	2	MIX	F	1,14	12	0	C,3	Simult	40	H
158	2	MIX	F	3,11	1	45	D,6	Simult	40	H
159	2	MIX	H	4,18	12	0,45	C,4	Simult	40	H
160	2	MIX	H	5,17	11,1	45	B,5	Simult	40	H
161	2	MIX	H	6,15	12,1	0,90	C,6	Simult	40	H
162	2	MIX	H	5,16	2,11	90,45	E,1	Simult	40	H
163	2	MIX	H	6,17	12	0	C,3	Simult	40	H
164	2	MIX	H	4,15	11	45	B,2	Simult	40	H
165	2	MIX	F,H	2,18	12	0,45	C,4	Simult	40	H
166	2	MIX	F,H	3,16	11,1	45	B,6	Simult	40	H
167	2	MIX	F,H	2,16	12,1	0,90	C,6	Simult	40	H
168	2	MIX	F,H	1,17	2,11	90,45	E,1	Simult	40	H
169	2	MIX	F,H	3,15	12	0	C,3	Simult	40	H
170	2	MIX	F,H	1,15	11	45	B,2	Simult	40	H
171	2	MIX	H,F	5,11	12	0,45	C,4	Simult	40	H
172	2	MIX	H,F	6,13	1,11	45	D,2	Simult	40	H
173	2	MIX	H,F	4,14	12,11	0,90	C,2	Simult	40	H
174	2	MIX	H,F	4,11	10,1	90,45	A,5	Simult	40	H
175	2	MIX	H,F	5,12	12	0	C,3	Simult	40	H
176	2	MIX	H,F	6,12	1	45	D,6	Simult	40	H
177	3	MIX	F	1,12,11	12,11,1	0,45,45	C,1,5	Simult	60	H
178	3	MIX	F	2,14,14	12	0	C,3,4	Simult	60	H
179	3	MIX	F	3,11,13	1,1,11	45	D,6,2	Simult	60	H
180	3	MIX	F	2,14,12	10,12,1	90,0,45	A,3,6	Simult	60	H
181	3	MIX	H	4,16,18	12,11,1	0,45,45	C,1,5	Simult	60	H
182	3	MIX	H	6,17,17	12	0	C,3,4	Simult	60	H
183	3	MIX	H	5,15,16	11,11,1	45	B,2,6	Simult	60	H
184	3	MIX	H	4,16,15	10,1,12	90,45,0	A,6,3	Simult	60	H
185	3	MIX	F,F,H	1,14,16	12,11,1	0,45,45	C,2,6	Simult	60	H
186	3	MIX	F,F,H	2,12,18	11,11,1	45,0,0	B,1,5	Simult	60	H
187	3	MIX	F,H,F	3,17,13	12	0	C,3,4	Simult	60	H
188	3	MIX	F,H,F	1,15,11	1,12,1	45	D,2,6	Simult	60	H

Scen No.	No. Targ	Type	Intent	Aircraft Model	Clock Azimuth	Degrees Aspect	Pattern /Stand	Pres. Order	Seconds Avail.	Diffic Level
189	3	MIX	F,H,H	2,16,18	2,1,12	90,45,0	E,6,4	Simult	60	H
190	3	MIX	F,H,H	3,17,17	12,11,1	45,45,0	C,1,5	Simult	60	H
191	3	MIX	F,H,H	2,18,15	10,11,12	90,45,45	A,2,3	Simult	60	H
192	3	MIX	H,H,F	4,15,12	12,11,1	0,45,45	C,2,6	Simult	60	H
193	3	MIX	H,H,F	5,16,11	11,11,1	45,0,0	B,1,5	Simult	60	H
194	3	MIX	H,H,F	5,15,11	11,11,1	45,0,0	B,2,6	Simult	60	H
195	3	MIX	H,F,H	6,14,18	12	0	C,3,4	Simult	60	H
196	3	MIX	H,F,H	4,13,17	1,12,1	45	D,2,6	Simult	60	H
197	3	MIX	H,F,H	6,14,17	1,11,12	45,90,90	D,2,6	Simult	60	H
198	3	MIX	H,F,F	5,13,12	2,1,12	90,45,0	E,6,4	Simult	60	H
199	3	MIX	H,F,F	6,11,11	12,11,1	45,45,0	C,1,5	Simult	60	H
200	3	MIX	H,F,F	4,14,12	10,11,12	90,45,45	A,2,3	Simult	60	H

AIRCRAFT MODEL TYPES

FRIENDLY	HOSTILE
FW:	FW:
1=A7	4=MiG27
2=A10	5=Su17
3=F16	6=Su25
RW:	RW:
11=AH64	15=Mi8
12=UH1	16=Mi24
13=UH60	17=Mi28
14=CH3	18=Mi? (Hokum)

FW AIRCRAFT PATTERNS

A -- 90 degree crossing pattern commencing at 10:00 azimuth

B -- 45 degree diagonal pattern commencing at 11:00 azimuth

C -- 0 degree ingress pattern commencing at 12:00 azimuth

D -- 45 degree diagonal pattern commencing at 1:00 azimuth

E -- 90 degree crossing pattern commencing at 2:00 azimuth

RW AIRCRAFT STANDS

1 -- 3 kilometer target at 11:00 azimuth

2 -- 5 kilometer target at 11:00 azimuth

3 -- 3 kilometer target at 12:00 azimuth

4 -- 5 kilometer target at 12:00 azimuth

5 -- 3 kilometer target at 1:00 azimuth

6 -- 5 kilometer target at 1:00 azimuth

2	4	6	5 km
1	3	5	3 km
11:00	12:00	1:00	

SCENARIO DIFFICULTY RATINGS

- Extra High Difficulty (XH). Refers to scenarios having 2 or more targets flying tactical maneuvers.

- High Difficulty (H). FW aircraft, due to their speed, maneuverability, range, and altitude present a more difficult adversary than their RW counterparts, especially when they ingress at zero aspect. A FW target presented simultaneously with multiple RW threats further taxes the soldiers' abilities. Mixed (FW and RW) scenarios thus represent a high degree of difficulty. Scenarios presenting multiple FW threats would likely be one or two levels of difficulty higher than this (XH).

- Medium High Difficulty (MH). Based on the definition of high difficulty given above, the next difficulty level reflects single FW targets presented at 0 to 45 degrees aspect.

- Medium Difficulty (M). This level reflects single, crossing FW scenarios at 90 degrees aspect. Also included are triple-simultaneous RW scenarios. The multiple RW threat makes for a challenging scenario in terms of soldier workload.

- Medium Low Difficulty (ML). This level represents the double-simultaneous RW scenario, and single or double-sequential RW scenarios presenting targets at maximum ranges or with small profiles (zero aspect). Moderate workload or moderate target visibility help to distinguish this from the lowest difficulty level.

- Low Difficulty (L). RW targets that are close in range or present a side view orientation are easy to detect and identify, and are rapidly engaged. Therefore, single, or double-sequential RW scenarios appear to be the easiest ones.

APPENDIX B

PROCEDURES FOR ASSESSING SCENARIO DIFFICULTY

Scenario Difficulty Weighting Procedure

1. A list was generated consisting of 14 difficulty factors having subfactors within each factor.

2. Five Subject Matter Experts (SME) weighted each factor for difficulty on a scale of from 1 to 100 (1=easiest, 100=hardest). The sum of the 14 factor weights always equaled 100.

3. Each of the 14 factors contained subfactors (e.g., Model Type factor contained a subfactor for each aircraft model being used). Each SME rated each subfactor for difficulty on a scale of 1 to 100 (subfactor values did not have to sum to 100).

4. 20 scenarios were developed. Each scenario was weighted using the factor and subfactor scores from each SME. Scenario difficulty scores represented subfactor weights multiplied by associated factor weights and summed over all 14 factors. Thus, a point total existed for each of the 20 scenarios for each SME.

5. For each SME, raw scenario scores were transformed to standard scores of 1 to 5 (1=low, 2=medium-low, 3=medium, 4=medium-high, 5=high) using the following procedure:

   a. Scenario scores were transformed into proportion scores by dividing each weight by the largest weighting score given by that specific SME. (Example: If an SME rated 3 scenarios 50, 55, 65, then each scenario would be turned into a proportion score with 65 as the denominator. 50/65=.77, 55/65=.85, 65/65=1.00.) Thus, each weighting score was turned into a proportion score with each base being that SME's highest rating, thereby controlling for differences between raters in highest score given and range of scores.

   b. Proportion scores ranged from lowest to 1.00 across all the 20 scenarios. This total range for each SME was divided into 5 equal-sized categories. (In the example above: Range was 1.00 minus 0.77=0.23. This .23 range was divided into 5 parts; .770-.816, .816-.862, .862-.908, .908-.954, .954-1.00.) These 5 equal-sized categories were given the numbers 1 to 5. (Lowest category=1, highest category=5)

6. SME's ratings (now labelled 1-5) were then summed and averaged for each of the 20 scenarios. That is, the mean SME rating was determined for each scenario. Each scenario was given a final label of L, ML, M, MH, or H which corresponded to the mean SME rating. This is how the SME weightings became difficulty indices for each of the 20 scenarios.

Factors

Criterion 1: Target Type (FW or RW) -- RW targets are generally easier to detect and identify than FW targets because they are usually closer in range upon initial line-of-sight, and do not roll, pitch, or yaw.

Criterion 2: Target Size -- Target model types vary from small (UH1) to large (MI8). The larger models are easier to see, and therefore to detect and identify.

Criterion 3: Target Model -- Soldiers are typically more familiar with some aircraft model types than others. For example, soldiers are better at identifying the Hind-D than the Havoc.

Criterion 4: Target Range -- Obviously, the farther away the target appears, the harder it is to detect and identify. This variable is especially relevant for RW targets as they do not vary in range once exposed. Thus, the farther away they are presented, the higher the LOD should be. For FW, the target will almost always begin its approach from beyond visible range when ingressing.

Criterion 5: Target Aspect and Offset -- Targets with side view orientations are easier to detect and to identify than face view (i.e., head-on) orientations because the target subtends a larger visual angle, and because more target features are visible. Further, the farther the target is from the fire unit's primary target line or from a cued azimuth, the longer it will take to detect it.

Criterion 6: Target Altitude -- Aircraft flying nap-of-the-earth or at extremely high altitudes are more difficult to see than those flying at moderate altitudes. Further, low targets are easier to see as the elevation above the terrain mask increases.

Criterion 7: Target Speed and Maneuverability -- Aircraft flying extremely fast will be harder to see and will present themselves for a shorter period of time than those flying at slower speeds. Further, maneuvering (dynamic) targets will be harder to detect and engage than static ones.

Criterion 8: Target Intent (Friendly or Hostile) -- RADES research has demonstrated that air defenders are typically faster and more accurate in responding to hostile targets than friendly targets. They tend to adopt "hostile expectancies" whereby the target default is hostile when there is doubt about its intent.

Criterion 9: Visibility and Contrast Conditions -- While the typical simulation environment will have clear weather, daylight, sky background, and non-obscured viewing conditions, this will not always be the case in real life situations. In order to generalize a scenario to other viewing situations, there must be some metric to gauge the extent to which reduced visibility will increase difficulty level. Visibility can be affected by atmospheric conditions (e.g. rain, etc.), windspeed, cloudiness, battlefield obscurants, etc.

Criterion 10: Terrain Conditions -- While the typical simulation environment will be the desert environment with a sky target background, such is not always the case in the real world. Greater difficulty would be expected for environments having more dense terrain, terrain target occulting (obscuration), or a lower contrast ratio between target and background.

Criterion 11: Weather Conditions -- It is well known that performance will drop as a result of extreme temperatures or weather conditions. This criterion relates only to the effect of weather on the soldier's physical abilities, and not on visibility which was covered previously.

Criterion 12: Number of Targets -- More than one target can improve detection time since there is a greater likelihood that a target will appear in the observer's field-of-view. However, multiple targets may also create confusion or panic in the other engagement tasks since it becomes more difficult to sort out the friends from the foes, and engage the target posing the greatest threat. Therefore, multiple target scenarios are usually associated with greater difficulty.

Criterion 13: Saturation Level -- This criterion relates primarily to workload level as influenced by battlefield situations. The more fatigued, tired, or inattentive the soldier is, the poorer his performance will be. A fire unit that has reacted to 30 scenarios will likely be more tired than one that has only responded to 3 scenarios during the same time frame; but the level of expectancy for that fire unit will likely be greater as well, while the latter fire unit may be less attentive. Generally, higher saturation level is equated to greater difficulty.

Criterion 14: C3I Conditions -- The use of doctrine, tactics, and C3I vary from one scenario to another and can cause drastic effects on performance, especially if the relevant information is not easily interpretable or if it is untimely or inaccurate. Combinations of message traffic or alerting and cuing updates can be consistent or conflicting; the more conflicting the inputs, the more confusion that ensues, resulting in either hesitation or panic on the part of the fire unit. For example, inputs such as WCS free, air defense warning red, and IFF return unknown are all consistent in suggesting that an approaching aircraft is hostile. This would substantially lower the difficulty level.

Subfactors

Criterion 1: Target Type
FW, RW, or Mixed

Criterion 2: Target Size
Small (UH1 or A7)
Medium (AH64 or A10)
Large (MI24 or SU17)
Extra Large (MI8 or SU24)

Criterion 3: Target Model
FW: A7 (Corsair), A10 (Thunderbolt), F16 (Fighting Falcon), F111, SU7 (Fitter), SU17/20/22 (Fitter), SU24 (Fencer), SU25 (Frogfoot), MIG27 (Flogger)
RW: UH1 (Iroquois), UH60 (Blackhawk), AH1 (Cobra), AH64 (Apache), CH3 (Green Giant), MI8 (Hip), MI24 (Hind), MI28 (Havoc), MI? (Hokum)

Criterion 4: Target Range
1-2 km, 3-4 km, 5-6 km, 7-8 km, 9-10 km, 11-14 km, 15-20 km

Criterion 5: target Aspect
90 degrees (side view)
60 degrees (side-tail view)
60 degrees (side-face view)
30 degrees (side-tail view)
30 degrees (side-face view)
0 degrees (tail view)
0 degrees (face view)

Criterion 6: Target Altitude
0 - 1 degrees above horizon
1.5 - 3 degrees above horizon
3.5 - 5 degrees above horizon
6 - 10 degrees above horizon
11 - 15 degrees above horizon
16 - 25 degrees above horizon

Criterion 7: Target Speed (based on 1/7 scale aircraft)
- 0 - 10 Mph (RW hover)
- 40 - 70 Mph (RW maneuver)
- 90 - 120 Mph (FW maneuver)
- 120 - 180 Mph (FW flyby)

Criterion 8: Target Intent
Friendly or Hostile

Criterion 9: Visibility and Contrast Conditions
1-2 km, 3-5 km, 6-10 km, 11-20 km, 21-40 km, 41+ km
Clear Sky, Partly Cloudy, Overcast

Criterion 10: Terrain Conditions
Desert, Forest, Jungle
Sky Background, Terrain Background

Criterion 11: Weather Conditions
- -10 to 20 degrees F
- 21 -- 40 degrees F
- 41 -- 60 degrees F
- 61 -- 80 degrees F
- 81 --100 degrees F
- 101+ degrees F

Criterion 12: Number of Targets
1, 2, 3, 4, or 5

Criterion 13: Saturation Level
Scenarios per day:
- 1 - 2 Scenarios per day
- 3 - 9 Scenarios per day
- 10 - 24 Scenarios per day
- 25 - 40 Scenarios per day
- 41+ Scenarios per day

Arousal Level:
Fresh, Average, Fatigued

Criterion 14: C^3I Conditions
Alert, WCS, IFF:
- Red, Free
- Red, Tight
- Red, Free, & IFF Unknown
- Red, Free, & IFF Possible Friend
- Red, Tight, & IFF Unknown
- Red, Tight, & IFF True Friend

Alerting and Cuing
- Alert Once per Day
- Alert Once per Trial
- Alert & Cue (+ / -15 degrees accuracy)
- Alert & Cue (+ / -5 degrees accuracy)

APPENDIX C

DESCRIPTIVE STATISTICS ON 20 STANDARD SCENARIOS

Table C1
Scenario Descriptive Statistics (Range=kilometers; Time=seconds; Proportion=percent; N=number of teams)

SCENARIO 1 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(A10)	RDET	12.2	3.3	6
	RIFF	10.0	3.7	4
	RID	7.3	2.5	6
	TID	17.7	8.4	6
	RACQ	7.5	0.0	1
	IDCOR	0.83	0.41	6
	FIRED	0.00	0.00	6
	FRAT	0.00	----	6

SCENARIO 2 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(F16)	RDET	10.5	2.0	6
	RIFF	9.6	2.5	6
	RID	7.8	2.5	5
	TID	14.8	4.5	5
	RACQ	8.5	0.9	5
	RLOCK	6.6	0.8	3
	RFIRE	7.0	0.5	2
	TTOT	25.5	16.3	2
	IDCOR	0.50	0.55	6
	FIRED	0.33	0.52	6
	EFFECT	0.00	0.00	2
	FRAT	0.00	----	6

SCENARIO 3 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(F111)	RDET	7.6	0.7	7
	RIFF	6.9	0.7	7
	RID	5.7	0.3	7
	TID	12.4	4.1	7
	RACQ	6.0	0.4	4
	RLOCK	5.2	0.0	2
	RFIRE	5.2	0.0	1
	TTOT	26.0	0.0	1
	IDCOR	0.71	0.49	7
	FIRED	0.14	0.38	7
	EFFECT	0.00	0.00	1
	FRAT	0.00	----	7

SCENARIO 4 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(MIG27)	RDET	10.7	2.8	7
	RIFF	8.6	4.0	7
	RID	4.2	0.7	7
	TID	18.1	6.5	7
	RACQ	4.6	1.5	7
	RLOCK	3.1	1.0	6
	RFIRE	2.6	1.1	6
	TTOT	24.3	5.0	6
	IDCOR	0.86	0.38	7
	FIRED	0.86	0.38	7
	EFFECT	1.00	0.00	6
	ATTRIT	0.86	----	7
	ORD	1.00	0.00	7

Table C1 (Continued)
Scenario Descriptives

SCENARIO 5 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(SU25)	RDET	11.6	2.9	3
	RIFF	8.7	0.3	3
	RID	7.2	0.8	2
	TID	18.0	8.5	2
	RACQ	5.5	1.2	3
	RLOCK	5.2	0.0	1
	RFIRE	4.8	0.1	2
	TTOT	28.0	11.3	2
	IDCOR	0.67	0.58	3
	FIRED	0.67	0.58	3
	EFFECT	0.50	0.71	2
	ATTRIT	0.33	----	3
	ORD	1.00	----	3

SCENARIO 6 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(SU24)	RDET	7.8	0.7	7
	RIFF	7.3	0.5	7
	RID	5.8	0.3	7
	TID	13.6	3.3	7
	RACQ	6.2	0.4	7
	RLOCK	5.8	0.4	7
	RFIRE	5.9	0.6	7
	TTOT	19.7	3.3	7
	IDCOR	0.67	0.58	3
	FIRED	1.00	0.00	7
	EFFECT	0.57	0.53	7
	ATTRIT	0.57	----	7
	ORD	0.00	0.00	7

SCENARIO 7 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(UH60)	TDET	3.4	1.1	7
	TIFF	3.0	2.8	7
	TID	8.7	4.2	7
	TACQ	5.3	1.6	6
	TLOCK	2.7	0.6	3
	TFIRE	3.0	0.0	1
	TTOT	10.0	0.0	1
	IDCOR	0.57	0.53	7
	FIRED	0.14	0.38	7
	EFFECT	1.00	0.00	1
	FRAT	0.14	----	7

SCENARIO 8 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(CH3)	TDET	2.7	2.0	7
	TIFF	5.8	6.8	5
	TID	4.1	2.0	7
	TACQ	3.7	1.9	4
	TLOCK	2.7	1.2	3
	TFIRE	3.0	0.0	2
	TTOT	9.0	1.0	3
	THAND	5.3	1.5	3
	IDCOR	0.29	0.49	7
	FIRED	0.43	0.53	7
	EFFECT	0.67	0.58	3
	FRAT	0.29	----	7

Table C1 (Continued)
Scenario Descriptives

SCENARIO 9 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(MI?)	TDET	4.5	3.6	8
	TIFF	1.5	1.Ø	7
	TID	5.7	3.Ø	8
	TACQ	5.Ø	2.2	7
	TLOCK	2.6	1.Ø	7
	TFIRE	3.6	3.4	7
	TTOT	11.1	4.3	7
	THAND	6.5	4.8	6
	IDCOR	Ø.87	Ø.35	8
	FIRED	Ø.87	Ø.35	8
	EFFECT	Ø.86	Ø.38	7
	FRAT	Ø.75	----	8
	ORD	Ø.62	Ø.52	8

SCENARIO 1Ø DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(MI8)	TDET	5.5	6.8	8
	TIFF	1.7	1.1	7
	TID	5.2	3.Ø	8
	TACQ	4.9	2.Ø	8
	TLOCK	2.Ø	Ø.6	7
	TFIRE	2.3	Ø.8	6
	TTOT	9.1	2.9	6
	THAND	4.6	1.8	5
	IDCOR	Ø.87	Ø.35	8
	FIRED	Ø.75	Ø.46	8
	EFFECT	Ø.67	Ø.51	6
	FRAT	Ø.5Ø	----	8
2(MI8)	TDET	22.7	1.2	6
	TIFF	2.2	1.9	5
	TID	4.7	1.9	6
	TACQ	5.4	2.1	3
	TLOCK	2.3	2.1	3
	TFIRE	2.Ø	Ø.Ø	3
	TTOT	9.7	2.2	4
	THAND	4.7	1.5	4
	IDCOR	Ø.75	Ø.46	8
	FIRED	Ø.5Ø	Ø.53	8
	EFFECT	Ø.25	Ø.5Ø	4
	ATTRIT	Ø.12	----	8
	ORD	Ø.87	Ø.35	8

Table C1 (Continued)
Scenario Descriptives

SCENARIO 11 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(MI24)	TDET	3.6	1.4	7
	TIFF	8.9	6.9	7
	TID	5.0	1.8	6
	TACQ	4.6	3.0	5
	TLOCK	3.0	1.0	4
	TFIRE	2.3	0.6	3
	TTOT	9.0	2.0	3
	THAND	3.7	3.2	3
	IDCOR	0.57	0.53	7
	FIRED	0.43	0.53	7
	EFFECT	1.00	0.00	3
	ATTRIT	0.43	----	7
2(MI24)	TDET	25.2	3.3	5
	TIFF	2.7	2.9	4
	TID	2.2	1.3	5
	TACQ	3.4	2.1	5
	TLOCK	2.0	0.8	4
	TFIRE	1.7	1.0	4
	TTOT	6.4	3.6	5
	THAND	4.2	2.4	5
	IDCOR	0.71	0.49	7
	FIRED	0.71	0.49	7
	EFFECT	0.00	0.00	5
	ATTRIT	0.0	----	7
	ORD	0.86	0.38	7

SCENARIO 12 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(AH1)	TDET	4.0	1.9	8
	TIFF	1.9	1.1	8
	TID	6.2	2.8	8
	TACQ	5.6	1.7	5
	TLOCK	5.0	2.8	2
	TFIRE	2.0	0.0	1
	TTOT	11.0	0.0	1
	THAND	7.0	0.0	1
	IDCOR	0.87	0.35	8
	FIRED	0.12	0.35	8
	EFFECT	1.00	0.00	1
	FRAT	0.12	----	8
2(UH1)	TDET	31.1	7.7	8
	TIFF	3.7	4.2	8
	TID	4.7	2.3	8
	TACQ	2.8	1.5	6
	TLOCK	3.7	3.1	3
	TFIRE	1.0	0.0	2
	TTOT	6.7	2.1	3
	THAND	1.5	0.7	2
	IDCOR	0.37	0.52	8
	FIRED	0.37	0.52	8
	EFFECT	0.67	0.58	3
	FRAT	0.25	----	8

Table C1 (Continued)
Scenario Descriptives

SCENARIO 13 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(MI8)	TDET	5.7	3.4	8
	TIFF	9.3	8.5	7
	TID	6.6	2.9	8
	TACQ	5.5	4.4	8
	TLOCK	6.1	9.7	8
	TFIRE	2.4	1.3	7
	TTOT	11.4	3.4	7
	THAND	5.Ø	3.3	7
	IDCOR	Ø.87	Ø.35	8
	FIRED	Ø.87	Ø.35	8
	EFFECT	Ø.43	Ø.53	7
	ATTRIT	Ø.37	----	8
	ORD	1.ØØ	Ø.ØØ	8
2(MI24)	TDET	33.5	3.Ø	6
	TIFF	Ø.8	1.Ø	6
	TID	8.Ø	3.2	6
	TACQ	6.Ø	5.2	5
	TLOCK	2.2	Ø.5	4
	TFIRE	3.2	2.2	4
	TTOT	12.5	5.5	4
	THAND	5.Ø	4.5	4
	IDCOR	Ø.37	Ø.52	8
	FIRED	Ø.5Ø	Ø.53	8
	EFFECT	Ø.5Ø	Ø.57	4
	ATTRIT	Ø.25	----	8
	ORD	1.ØØ	Ø.ØØ	8

SCENARIO 14 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(CH3	TDET	2.5	1.Ø	7
or	TIFF	3.9	4.7	7
MI8)	TID	6.Ø	1.6	7
	TACQ	5.7	1.5	6
	TLOCK	3.2	2.5	6
	TFIRE	2.3	1.5	6
	TTOT	11.2	2.7	6
	THAND	5.Ø	1.8	6
	IDCOR	Ø.14	Ø.38	7
	FIRED	Ø.86	Ø.38	7
	EFFECT	1.ØØ	Ø.ØØ	6
2(CH3	TDET	2Ø.4	7.5	7
or	TIFF	3.6	5.5	7
MI8)	TID	4.9	2.3	7
	TACQ	7.4	6.Ø	7
	TLOCK	3.9	2.3	7
	TFIRE	1.7	Ø.5	7
	TTOT	13.Ø	5.4	7
	THAND	8.1	5.8	7
	IDCOR	1.ØØ	Ø.ØØ	7
	FIRED	1.ØØ	Ø.ØØ	7
	EFFECT	Ø.71	Ø.49	7
CH3	IDCOR	Ø.14	Ø.38	7
	FIRED	Ø.86	Ø.38	7
	EFFECT	1.ØØ	Ø.ØØ	6
	FRAT	Ø.86	Ø.38	7
MI8	IDCOR	1.ØØ	Ø.ØØ	7
	FIRED	1.ØØ	Ø.ØØ	7
	EFFECT	Ø.71	Ø.49	7
	ATTRIT	Ø.71	----	7
	ORD	1.ØØ	Ø.ØØ	7

Table C1 (Continued)
Scenario Descriptives

SCENARIO 15 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(MI8	TDET	3.1	1.3	7
or	TIFF	3.6	5.1	5
MI28	TID	4.7	1.9	7
or	TACQ	3.9	2.5	7
MI24)	TLOCK	3.2	1.5	6
	TFIRE	2.2	0.5	5
	TTOT	8.8	1.3	6
	THAND	4.3	0.8	6
	IDCOR	0.86	0.38	7
	FIRED	0.71	0.49	7
	EFFECT	0.80	0.45	5
2(MI8	TDET	17.6	2.0	7
or	TIFF	0.8	1.0	6
MI28	TID	4.2	1.2	6
or	TACQ	4.7	1.5	6
MI24)	TLOCK	2.5	1.4	6
	TFIRE	2.2	0.8	6
	TTOT	9.3	1.4	6
	THAND	5.2	0.8	6
	IDCOR	0.86	0.38	7
	FIRED	0.86	0.38	7
	EFFECT	1.00	0.00	6
3(MI8	TDET	30.7	4.0	7
or	TIFF	3.0	2.8	7
MI28	TID	8.4	3.8	7
or	TACQ	6.2	4.2	6
MI24)	TLOCK	3.4	1.9	5
	TFIRE	1.8	0.4	5
	TTOT	12.8	4.9	5
	THAND	4.0	1.9	5
	IDCOR	0.86	0.38	7
	FIRED	0.71	0.49	7
	EFFECT	0.40	0.55	5
MI8	IDCOR	1.00	0.00	7
	FIRED	1.00	0.00	7
	EFFECT	0.86	0.38	7
	ATTRIT	0.86	----	7
	ORD	1.00	0.00	7
MI28	IDCOR	0.71	0.49	7
	FIRED	0.71	0.49	7
	EFFECT	1.00	0.00	5
	ATTRIT	0.71	----	7
	ORD	1.00	0.00	7
MI24	IDCOR	0.86	0.38	7
	FIRED	0.57	0.53	7
	EFFECT	0.25	0.50	4
	ATTRIT	0.14	----	7
	ORD	1.00	0.00	7

SCENARIO 16 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(AH1	TDET	8.9	12.9	7
or	TIFF	3.5	4.4	6
MI28	TID	5.3	3.7	6
or	TACQ	7.3	2.1	3
MI24)	TLOCK	3.8	1.1	5
	TFIRE	4.2	6.0	4
	TTOT	8.7	5.2	4
	THAND	6.0	6.4	5
	IDCOR	0.71	0.49	7
	FIRED	0.71	0.49	7
	EFFECT	0.60	0.54	5
2(AH1	TDET	18.6	7.5	5
or	TIFF	4.0	4.1	5
MI28	TID	6.4	2.2	5
or	TACQ	3.2	2.2	5
MI24)	TLOCK	5.3	3.1	3
	TFIRE	2.0	1.0	3
	TTOT	8.7	3.8	4
	THAND	2.7	3.2	4
	IDCOR	0.57	0.53	7
	FIRED	0.57	0.53	7
	EFFECT	0.50	0.58	4
3(AH1	TDET	31.8	8.3	5
or	TIFF	1.0	1.0	3
MI28	TID	6.5	1.3	4
or	TACQ	4.0	2.7	4
MI24)	TLOCK	4.0	0.0	1
	TFIRE	2.0	0.0	1
	TTOT	17.7	10.0	3
	THAND	11.7	10.8	3
	IDCOR	0.43	0.53	7
	FIRED	0.57	0.53	7
	EFFECT	0.00	0.00	3
AH1	IDCOR	0.57	0.53	7
	FIRED	0.57	0.53	7
	EFFECT	0.25	0.50	4
	FRAT	0.14	----	7
MI24	IDCOR	0.57	0.53	7
	FIRED	0.71	0.49	7
	EFFECT	0.60	0.55	5
	ATTRIT	0.43	----	7
	ORD	1.00	0.00	7
MI28	IDCOR	0.57	0.53	7
	FIRED	0.43	0.53	7
	EFFECT	0.33	0.58	3
	ATTRIT	0.14	----	7
	ORD	1.00	0.00	7

Table C1 (Continued)
Scenario Descriptives

SCENARIO 17 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(CH3	TDET	1.3	0.5	7
or	TIFF	2.3	2.4	7
MI28	TID	4.0	1.8	7
or	TACQ	4.4	1.3	5
UH1)	TLOCK	2.2	1.6	5
	TFIRE	1.8	0.8	5
	TTOT	8.4	1.8	5
	THAND	4.6	2.3	5
	IDCOR	0.81	0.49	7
	FIRED	0.71	0.49	7
	EFFECT	1.00	0.00	5
2(CH3	TDET	13.1	1.8	7
or	TIFF	2.4	2.9	7
MI28	TID	4.1	2.9	7
or	TACQ	3.2	2.2	4
UH1)	TLOCK	2.0	1.4	2
	TFIRE	2.0	0.0	3
	TTOT	7.7	1.5	3
	THAND	5.0	0.0	3
	IDCOR	0.57	0.53	7
	FIRED	0.43	0.53	7
	EFFECT	0.67	0.58	3
3(CH3	TDET	25.3	4.9	7
or	TIFF	3.5	6.7	6
MI28	TID	7.3	5.3	7
or	TACQ	5.5	1.3	4
UH1)	TLOCK	3.0	1.4	2
	TFIRE	3.5	1.7	4
	TTOT	10.6	3.2	5
	THAND	4.2	2.1	4
	IDCOR	0.29	0.49	7
	FIRED	0.71	0.49	7
	EFFECT	0.20	0.45	5
CH3	IDCOR	0.14	0.38	7
	FIRED	0.86	0.38	7
	EFFECT	0.67	0.52	6
	FRAT	0.57	----	7
MI28	IDCOR	0.71	0.49	7
	FIRED	0.71	0.49	7
	EFFECT	0.80	0.45	5
	ATTRIT	0.57	----	7
	ORD	0.57	0.53	7
UH1	IDCOR	0.71	0.49	7
	FIRED	0.29	0.49	7
	EFFECT	0.00	0.00	2
	FRAT	0.00	0.00	7

SCENARIO 18 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(A7)	RDET	11.1	2.2	6
	RIFF	7.5	3.7	5
	RID	5.0	3.7	6
	TID	21.2	11.1	6
	RACQ	5.5	1.3	3
	RLOCK	4.4	0.0	1
	RFIRE	3.6	0.1	2
	TTOT	29.0	15.6	2
	IDCOR	0.83	0.41	6
	FIRED	0.33	0.52	6
	EFFECT	0.50	0.71	2
	FRAT	0.17	----	6
2(MI24)	TDET	9.5	4.9	2
	TIFF	1.0	0.0	1
	TID	3.0	0.0	1
	TACQ	5.0	0.0	1
	TLOCK	2.0	0.0	2
	TFIRE	7.0	7.1	2
	TTOT	9.0	0.0	1
	THAND	11.0	7.1	2
	IDCOR	0.33	0.52	6
	FIRED	0.33	0.52	6
	EFFECT	0.50	0.71	2
	ATTRIT	0.17	----	6
	ORD	1.00	0.00	6

Table C1 (Continued)
Scenario Descriptives

SCENARIO 19 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(MI? or MI28)	TDET	3.8	1.9	5
	TIFF	11.0	13.7	4
	TID	7.8	7.1	5
	TACQ	8.7	6.7	4
	TLOCK	4.6	3.1	5
	TFIRE	5.7	6.4	4
	TTOT	16.7	7.7	4
	THAND	8.0	9.4	4
	IDCOR	0.80	0.45	5
	FIRED	0.80	0.45	5
	EFFECT	1.00	0.00	4
2(MI? or MI28)	TDET	30.2	11.3	6
	TIFF	2.8	3.6	5
	TID	5.0	3.9	6
	TACQ	4.0	1.8	6
	TLOCK	8.0	14.5	5
	TFIRE	2.0	0.7	5
	TTOT	14.2	14.6	5
	THAND	9.6	10.4	5
	IDCOR	0.67	0.52	6
	FIRED	0.83	0.41	6
	EFFECT	0.75	0.50	4
3(SU17)	RDET	14.6	1.7	2
	RIFF	7.7	3.0	2
	RID	6.7	4.2	2
	TID	26.5	9.2	2
	RACQ	6.1	3.7	2
	RLOCK	5.3	3.0	2
	RFIRE	4.8	2.6	2
	TTOT	36.0	7.1	2
	IDCOR	1.00	0.00	2
	FIRED	1.00	0.00	2
	EFFECT	1.00	0.00	2
	ATTRIT	0.29	---	7
	ORD	0.50	0.71	2
MI?	IDCOR	0.86	0.38	7
	FIRED	0.86	0.38	7
	EFFECT	0.83	0.41	6
	ATTRIT	0.71	----	7
	ORD	1.00	0.00	7
MI28	IDCOR	0.57	0.53	7
	FIRED	0.71	0.49	7
	EFFECT	1.00	0.00	4
	ATTRIT	0.57	-----	7
	ORD	0.57	0.53	7

SCENARIO 20 DESCRIPTIVES

TARGET	VARIABLE	MEAN	SD	N
1(SU25)	RDET	12.6	2.0	7
	RIFF	10.5	2.3	6
	RID	4.4	2.4	6
	TID	27.0	10.3	6
	RACQ	6.4	2.9	6
	RLOCK	3.4	1.4	5
	RFIRE	2.3	0.7	5
	TTOT	34.8	8.0	5
	IDCOR	0.71	0.49	7
	FIRED	0.71	0.49	7
	EFFECT	1.00	0.00	5
	ATTRIT	0.71	----	7
	ORD	0.86	0.38	7
2(UH60 or MI8)	TDET	26.0	11.1	7
	TIFF	8.4	13.8	7
	TID	6.0	2.8	6
	TACQ	5.8	5.0	5
	TLOCK	3.6	2.7	5
	TFIRE	7.6	10.5	5
	TTOT	16.4	7.6	5
	THAND	9.5	9.7	4
	IDCOR	0.71	0.49	7
	FIRED	0.71	0.49	7
	EFFECT	0.50	0.58	4
UH60	IDCOR	0.50	0.58	4
	FIRED	0.33	0.52	6
	EFFECT	1.00	0.00	2
	FRAT	0.33	----	6
MI8	IDCOR	0.29	0.49	7
	FIRED	0.43	0.53	7
	EFFECT	0.00	0.00	2
	ATTRIT	0.00	----	7
	ORD	1.00	0.00	7

NOTE: No engagement data on target number 3